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Regiochemical Control of the Ring Opening of 1,2-Epoxides by Means of Chelating Processes.10. Synthesis and Ring Opening Reactions of Mono- and Difunctionalized cis and trans Aliphatic Oxirane Systems[1]

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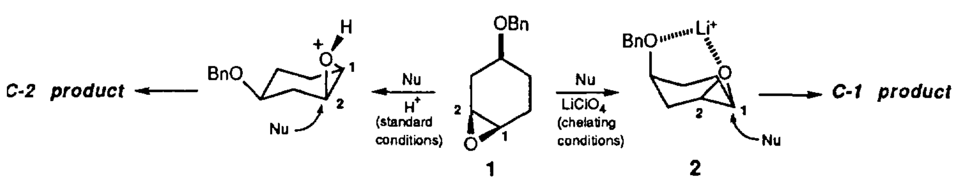
Abstract : The regiochemical outcome of the ring opening of 1,2-epoxides through chelation processes assisted by metal ions, was verified in mono- and difunctionalized aliphatic oxirane systems bearing the heterofunctionality (OR) in an homoallylic and/or allylic relationship to the oxirane ring. The effect of the distance of the OR functionality from the oxirane ring and of the type of protective group on the regiochemical outcome of these systems is examined. In some cases, the use of $LiClO_4$ or $Mg(ClO_4)_2$ as the promoting metal salt makes it possible the obtainment of a nice regioalternating process.

The ring opening reactions of simple aliphatic functionalized 1,2-epoxides, if carried out under conditions of stereo- and regiochemical control, can make it possible to obtain simple molecules with a well-defined structure and configuration, which can be utilized as "building blocks" for the construction of more complex molecules.

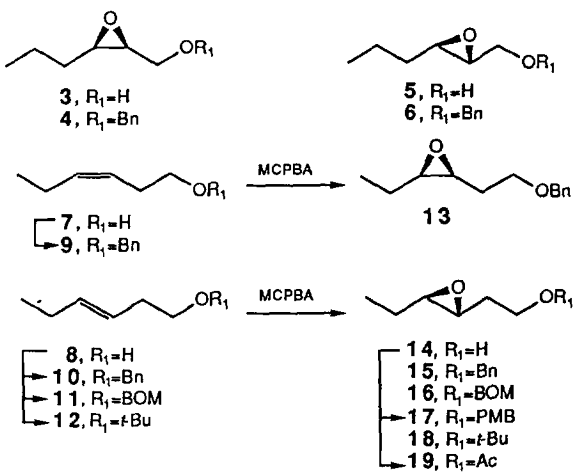
As a result of the complete anti stereoselectivity commonly observed in the ring opening reactions of aliphatic and cycloaliphatic 1,2-epoxides,[2] much effort has been devoted to devising simple procedures which allow a high degree of regiocontrol.[3,4] In this sense, the introduction of a remote heterofunctionality (OBn) into the cyclohexene oxide framework turned out to be particularly effective. For example, the almost complete C-2 selectivity observed in the opening reactions of the functionalized epoxide cis **1** with a large variety of nucleophiles (Nu), could be reversed by carrying out the opening reactions in the presence of a metal salt ($LiClO_4$). This result was attributed to the incursion of the chelate bidentate species **2** in the reaction medium.[4g-i]



1 **2**

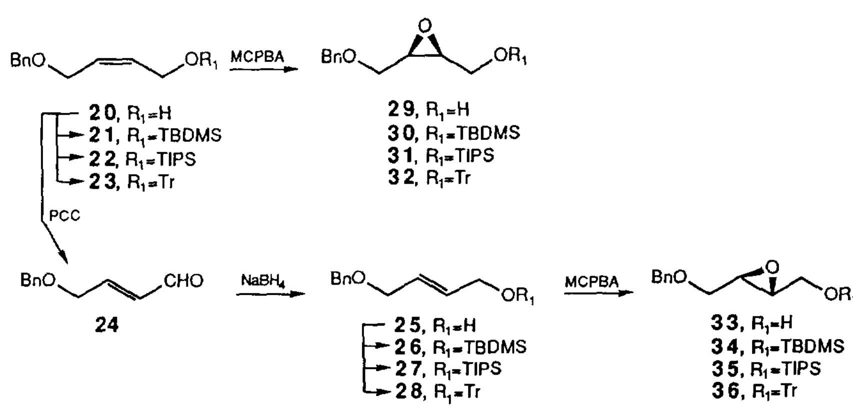
In the non-cyclic aliphatic series, the corresponding studies on regiochemical behavior with different nucleophiles have been confined only to 1,2-epoxides, such as the cis **3-4** and trans **5-6** epoxides, with a free (OH) or a protected (OBn) heterofunctionality in an allylic relationship to the oxirane ring; interesting regioselective results have been obtained by Pfaltz (Me⁻ transfer reaction),[5] Sharpless, and our group (nucleophiles other than Me⁻).[3,4d] Other monofunctionalized or difunctionalized aliphatic oxirane systems, such as the cis **13** and trans **15** (Scheme 1), cis **29** and trans **33** epoxides (Scheme 2), had previously been examined, too, but these studies exclusively concerned alkyl or aryl transfer reactions,[5-7] while, to our knowledge, nothing is known about the addition reactions to these systems of some other nucleophile.

Scheme 1

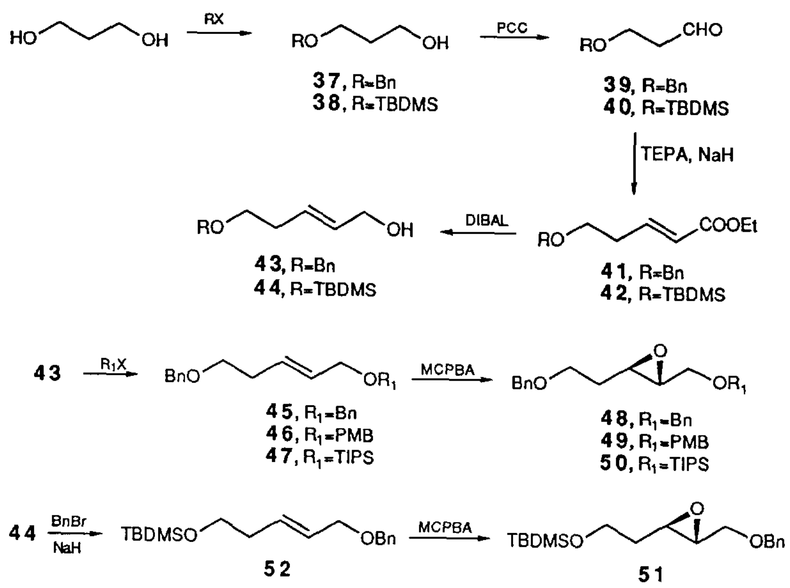


In the present study, we decided to extend the examination of the regiochemical outcome of the ring-opening reactions of aliphatic oxirane systems with a nucleophile different from Me⁻, firstly to the monofunctionalized cis **13** and trans **14-19** epoxides (Scheme 1), the regioisomers of the previously studied cis **3-4** and trans **5-6** epoxides,[3,4d] and subsequently to more complex systems, such as the cis **29-32** and trans **33-36** (Scheme 2), and trans **48-51** epoxides (Scheme 3) bearing two heterofunctionalities (free OH and/or OR groups) symmetrically (both allylic, epoxides **29-36**) or unsymmetrically disposed (one allylic and one homoallylic) with respect to the oxirane ring (epoxides **48-51**). In all cases, the use of different OH-

Scheme 2



Scheme 3



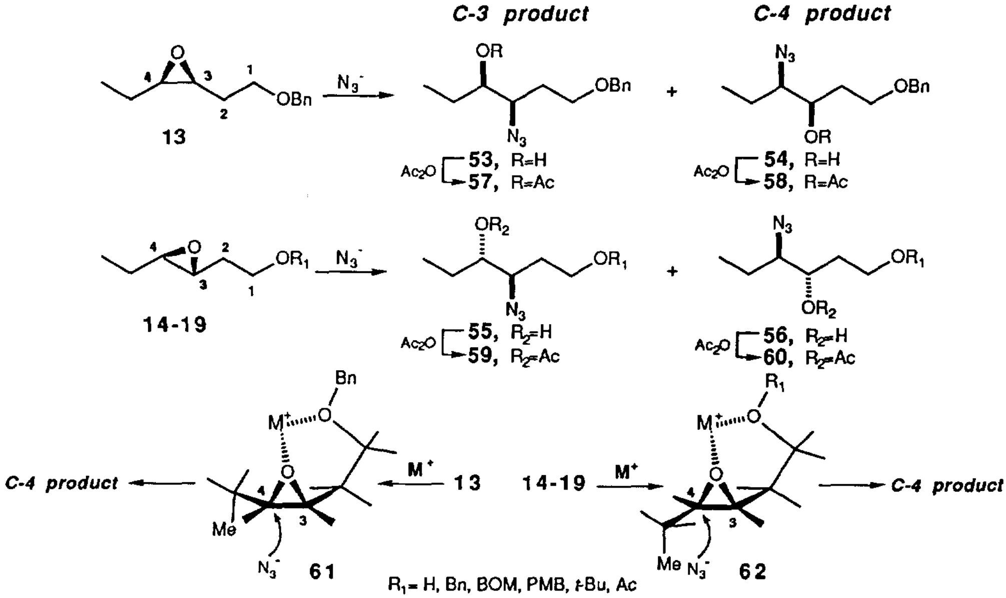
R_1X=BnBr, PMBCl, TIPSCl

protecting groups would have given information about their influence on the regiochemical outcome of these aliphatic oxirane systems.

The benzylation of the commercially available cis **7** and trans **8** alcohols afforded the corresponding cis **9** and trans **10** unsaturated ethers which were oxidized with MCPBA to the cis **13** and trans **15** epoxides, respectively.[6] The trans epoxides **14**, **16** and **18** were prepared by MCPBA oxidation of the corresponding trans olefin **8**, **11** and **12**, and the trans epoxides **17** and **19** by appropriate protection of the trans epoxy alcohol **14**. The cis **29** and trans **33** epoxides were obtained by MCPBA oxidation of the corresponding olefins **20** and **25**, respectively. Whereas cis olefin **20** is commercially available, trans olefin **25** was obtained by oxidation with pyridinium chlorochromate (PCC) of **20** to give the isomerized trans aldehyde **24**, followed by $NaBH_4$ reduction.[8] The cis **30-32** and trans **34-36** epoxides were prepared by MCPBA oxidation of the unsaturated ethers **21-23** and **26-28** obtained by protection of the corresponding unsaturated alcohols **20** and **25**, respectively (Scheme 2). The unsymmetrically disubstituted trans epoxides **48-51** were prepared in the following way.[9] The reaction of 1,3-propandiol with BnBr/NaH or *t*-butyldimethylsilyl chloride afforded the alcohols **37** and **38** which were oxidized with PCC to the aldehydes **39** and **40**, respectively. The Wittig reaction of **39** and **40** with the stabilized ylide[10] obtained by triethylphosphono-acetate (TEPA) and NaH selectively afforded the trans esters **41** and **42**, respectively, which were reduced with DIBAL to the corresponding trans alcohol **43** and **44**. The reaction of alcohols **43** and **44** with the appropriate halogenide afforded the corresponding unsaturated ethers **45-47** (from **43**) and **52** (from **44**) which were oxidized with MCPBA to give the trans epoxides **48-51** (Scheme 3).

All the epoxides prepared were subjected to the opening reaction with the azide ion (N_3^-), a classic nucleophile different from Me^-,[7] which we have exclusively taken into consideration for these regiochemical studies, both in consideration of the large interest for the corresponding opening products (the azido alcohols) and in view of its operative simplicity. The azidolysis reactions were carried out both with NaN_3/NH_4Cl in an 8:1 $MeOH/H_2O$ solution (standard conditions),[3,4] and with NaN_3 in MeCN (or MeOH, in some cases) in the presence of a metal salt such as $LiClO_4$ or $Mg(ClO_4)_2$ (chelating conditions).[4,11] The opening products from epoxides **13**-**19** (the azido alcohols **53**-**56**, Scheme 4) are simply named *C-3* and *C-4 products*, while the opening products from epoxides **29**-**36** (the azido alcohols **63**-**66**, Scheme 5) and from epoxides **48**-**51**

Scheme 4



(the azido alcohols **79**-**82**, Scheme 6) are simply named *C-2* and *C-3 products* depending on the site of attack of the nucleophile (N_3^-) in accordance with the numbering scheme shown in Schemes 4-6. In each case, the exact structure and regiochemistry of the azido alcohols was firmly established by examination of their ^1H NMR spectra and by appropriate double resonance experiments carried out on the corresponding monoacetyl (acetates **57**-**60**, and **83**-**86** from the azido alcohols **53**-**56**, and **79**-**82**, respectively, Schemes 4 and 6) or diacetyl derivatives (diacetates **71**-**74** from the azido alcohols **63**-**66**, Scheme 5). Diacetates **71**-**74** were obtained from the azido alcohols **63**-**66** through an acetylation-deprotection (AcOH in THF/H_2O)-acetylation sequence; in this way, the azido alcohols **63**-**66** [R_1=*t*-butyldimethylsilyl (TBDMS), triisopropylsilyl (TIPS), trityl (Tr)], which differ only for the type of the protective group, lead to the same corresponding diacetate **71**-**74**. The *C-2*/*C-3* or *C-3*/*C-4 product* ratio obtained in the azidolysis of the epoxides studied was determined by GC and/or by ^1H NMR examination of the crude monoacetylated reaction product, making use of the easily distinguishable and well-separated signal of the proton α to the acetyl group.

Results and Discussion

The results obtained with the cis **13** and trans **15** epoxides bearing an homoallylic heterofunctionality (OBn) appear to be influenced by the reaction conditions, even if to a lower extent than the corresponding allylic substituted cis **4** and trans **6** epoxides.[4d] While the azidolysis of **13** and **15** under standard conditions is almost non selective (59-62%), an appreciable C-4 selectivity (80-84%) is obtained under chelating conditions with $Mg(ClO_4)_2$ as the promoting metal salt ($LiClO_4$ appears to be less effective, Table 1). While the non-selective result obtained in the azidolysis of **13** and **15** under standard conditions appeared to be justified by the distance of the OBn functionality from the oxirane ring which makes the two oxirane carbons of **13** and **15** electronically and sterically almost equivalent, the interesting fair C-4 selectivity obtained in the same reaction carried out under chelating conditions can be easily rationalized by means of the intervention, in these operating conditions, of the chelate bidentate structure **61**, from the epoxide cis **13**, and **62** (R_1=Bn), from the trans

Table 1. Regioselectivity of the Azidolysis of the Epoxides cis 13 and trans 14-19.

entry	epoxide	reagents	solvent	*C-3 product*	*C-4 product*	yield %
1	**13** R_1=Bn	NaN_3-NH_4Cl	MeOH-H_2O	41	59	94
2	**13**	NaN_3-$LiClO_4$ 5M	MeCN	24	77	85
3	**13**	NaN_3-$Mg(ClO_4)_2$ 2.5M	MeCN	20	80	82
4	**14** R_1=H	NaN_3-NH_4Cl	MeOH-H_2O	54	46	89
5	**14**	NaN_3-$LiClO_4$ 5M	MeCN	42	58	91
6	**14**	NaN_3-$Mg(ClO_4)_2$ 2.5M	MeCN	29	71	90
7	**15** R_1=Bn	NaN_3-NH_4Cl	MeOH-H_2O	38	62	90
8	**15**	NaN_3-$LiClO_4$ 5M	MeCN	32	68	82
9	**15**	NaN_3-$Mg(ClO_4)_2$ 2.5M	MeCN	16	84	81
10	**16** R_1=BOM	NaN_3-NH_4Cl	MeOH-H_2O	29	71	89
11	**16**	NaN_3-$LiClO_4$ 5M	MeCN	29	71	82
12	**16**	NaN_3-$Mg(ClO_4)_2$ 2.5M	MeCN	20	80	84
13	**17** R_1=PMB	NaN_3-NH_4Cl	MeOH-H_2O	29	71	90
14	**17**	NaN_3-$LiClO_4$ 5M	MeCN	19	81	85
15	**17**	NaN_3-$Mg(ClO_4)_2$ 2.5M	MeCN	9	91	88
16	**18** R_1=*t*-Bu	NaN_3-NH_4Cl	MeOH-H_2O	38	62	95
17	**18**	NaN_3-$LiClO_4$ 5M	MeCN	18	82	86
18	**18**	NaN_3-$Mg(ClO_4)_2$ 2.5M	MeCN	42	58	88
19	**19** R_1=Ac	NaN_3-NH_4Cl	MeOH-H_2O	34	66	90
20	**19**	NaN_3-$LiClO_4$ 5M	MeCN	48	52	91
21	**19**	NaN_3-$Mg(ClO_4)_2$ 2.5M	MeCN	14	86	87

All the reactions were carried out at 80°C for 18 h.

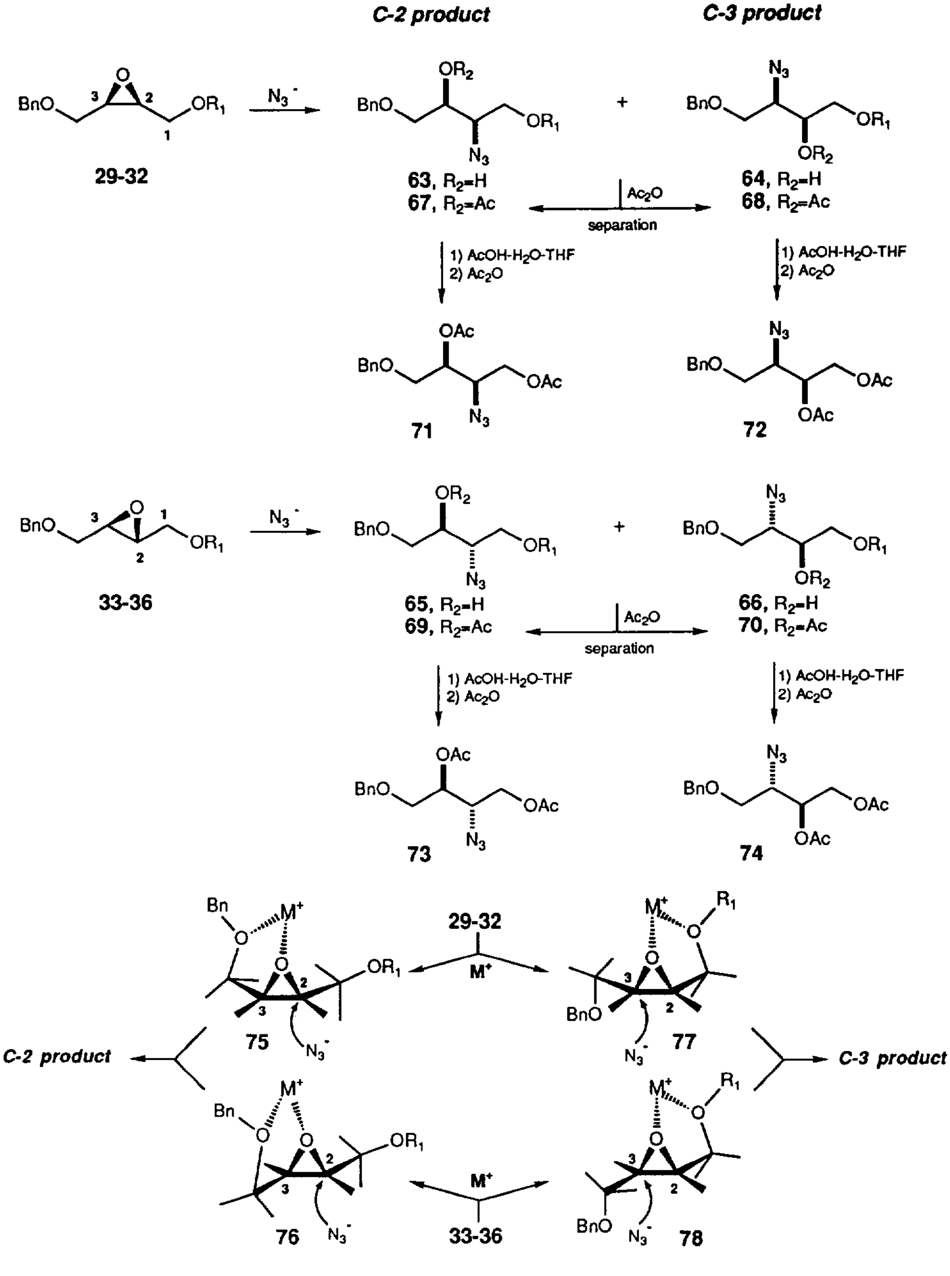
epoxide **15** (Scheme 4), of the same type as previously admitted for the corresponding methyl-transfer opening reactions.[6] In **61** and **62** (R_1=Bn), where the oxirane oxygen and the oxygen of the ether functionality (OR_1) are coordinated through the metal, the nucleophilic attack preferentially occurs on the C(4) oxirane carbon, as a consequence of all the stereolectronic factors implied in the ring opening process of these monofunctionalized oxirane systems.[3,4d,6] However, it is not easy to understand why in the present metal salt-promoted azidolysis of **13** and **15**, it was not possible to obtain the high regioselectivity level previously obtained by Pfaltz and Flippin in the same system in the Me^- transfer reactions.[5,6] This is also somewhat surprising considering that other oxirane systems such as **1** showed an almost identical regiochemical behavior both in the Me^- transfer reactions and in the metal salt-promoted azidolysis.[4g,4i]

As the type of OH-protective group present in the homoallylic heterofunctionality could be of some importance in the formation of the chelate bidentate species **61** and **62** (Scheme 4) and subsequently in the regiochemical outcome under chelating conditions, the protective benzyl group of the trans epoxide **15** was substituted with some other protective groups. Our choice was directed towards those protective groups [*p*-methoxybenzyl (PMB), *t*-butyl (*t*-Bu), benzyloxymethyl (BOM),[13] and acetyl (Ac)] which could be reasonably supposed to determine an increase in the amount of the chelate species **62** (R_1= protective group) in the reaction medium *i)* by increasing the electron density on the linked ether oxygen, as in the case of PMB and *t*-Bu protective group (epoxides **17** and **18**, Scheme 1) or *ii)* by the possible combined effect of more than one oxygen, as in the case of BOM and Ac protective group (epoxides **16** and **19**, Scheme 1).[14] Even if somewhat inferior to our expectations, the results obtained with the trans epoxides **16-19** confirm the importance of the protective group for the regiochemical outcome of these systems, and a significant increase in C-4 regioselectivity (*C-4/C-3 product* =91:9, entry 15, Table 1) is obtained when the PMB moiety is utilized as the protective group (epoxide **17**).

In the difunctionalized cis **29** and trans **33** epoxides, the two oxirane carbons are practically equivalent from the point of view of any electronic and steric considerations, and the azidolysis opening reactions carried out under standard conditions are accordingly not selective (*C-2/C-3 product*= 55:45, entries 1 and 11, Table 2). On the contrary, in the metal-assisted azidolysis reactions of **29** and **33**, two chelate bidentate species may reasonably be formed in the reaction medium: the chelate species **75** and **77** (R_1=H), from the cis epoxide **29**, and the chelate species **76** and **78** (R_1=H), from the trans epoxide **33**, in which the oxygen of the benzyloxy group (in **75** and **76**, R_1=H) or the oxygen of the free OH functionality (in **77** and **78**, R_1=H) is coordinated with the oxirane oxygen through the metal (Scheme 5). As the chelate species **75-76** and **77-78** (R_1=H) are preferentially attacked by the nucleophile at the C(2) and C(3) oxirane carbons, respectively, as a consequence of the above-mentioned stereoelectronic factors,[4d,6] the selective formation of **75-76** or **77-78** (R_1=H) in the reaction medium could be of decisive importance in determining the regiochemical results of the opening process of epoxides **29** and **33** in these conditions. The results obtained in the azidolysis of the cis **29** and trans **33** epoxides under chelating conditions show a slight C-2 regioselection (70-72%, entries 3 and 13, Table 2) which can be attributed to a preferential formation of the chelate species **75** and **76** (R_1=H), respectively. In other words, the metal appears to show a slight preference for coordination with the allylic OBn group rather than with the allylic free OH functionality, in accordance with some results obtained in the monofunctionalized oxirane system.[4d]

In order to favor further, under chelate operating conditions, the formation of the chelate species **75** and **76** from the cis **29** and trans **33** epoxides, respectively, we thought it useful to introduce on the free OH

Scheme 5



R1= H, TBDMS, TIPS, Tr

functionality some protective groups such as the TBDMS (cis **30** and trans epoxide **34**) and the TIPS group (cis **31** and trans epoxide **35**) which notoriously decrease the coordinative ability of the directly linked oxygen.[15] Moreover, pointing to a possible steric hindrance to coordination, the effect of the trityl protective group (Tr) was examined, too (cis **32** and trans epoxide **36**) (Schemes 2 and 5).

Table 2. Regioselectivity of the Azidolysis of the Difunctionalized Epoxides cis 29-32 and trans 33-36.

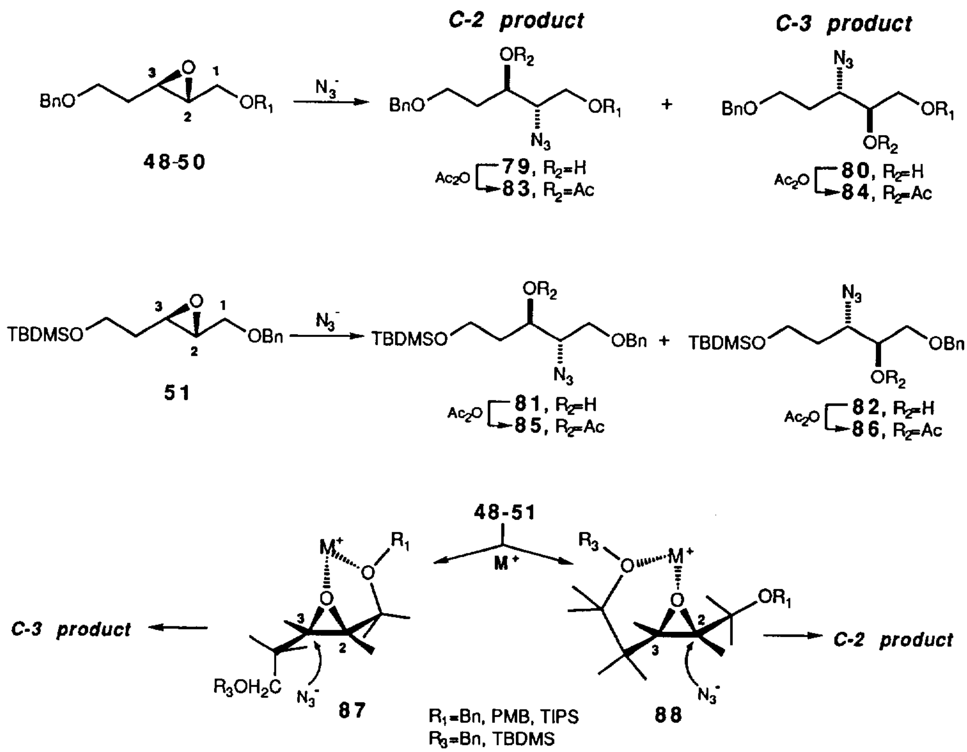
entry	epoxide	reagents	solvent	*C-2 product*	*C-3 product*	yield %
1	**29** R_1=H	NaN_3-NH_4Cl	MeOH-H_2O	57	43	91
2	**29**	NaN_3-NH_4ClO_4-$LiClO_4$ 5M	MeCN	61	39	89
3	**29**	NaN_3-NH_4ClO_4-$LiClO_4$ 17 M	MeOH	72	28	84
4	**30** R_1=TBDMS	NaN_3-NH_4Cl	MeOH-H_2O	58	42	94
5	**30**	NaN_3-NH_4ClO_4-$LiClO_4$ 5M	MeCN	64	36	87
6	**30**	NaN_3-NH_4ClO_4-$LiClO_4$ 17 M	MeOH	72	28	85
7	**31** R_1=TIPS	NaN_3-NH_4Cl	MeOH-H_2O	50	50	92
8	**31**	NaN_3-NH_4ClO_4-$LiClO_4$ 5M	MeCN	76	24	90
9	**32** R_1=Tr	NaN_3-NH_4Cl	MeOH-H_2O	63	37	82
10	**32**	NaN_3-NH_4ClO_4-$LiClO_4$ 5M	MeCN	80	20	85
11	**33** R_1=H	NaN_3-NH_4Cl	MeOH-H_2O	55	45	92
12	**33**	NaN_3-NH_4ClO_4-$LiClO_4$ 5M	MeCN	65	35	88
13	**33**	NaN_3-NH_4ClO_4-$LiClO_4$ 17 M	MeOH	70	30	88
14	**34** R_1=TBDMS	NaN_3-NH_4Cl	MeOH-H_2O	65	35	93
15	**34**	NaN_3-NH_4ClO_4-$LiClO_4$ 5M	MeCN	56	44	89
16	**34**	NaN_3-NH_4ClO_4-$LiClO_4$ 17 M	MeOH	60	40	79
17	**35** R_1=TIPS	NaN_3-NH_4Cl	MeOH-H_2O	66	34	90
18	**35**	NaN_3-NH_4ClO_4-$LiClO_4$ 5M	MeCN	75	25	87
19	**35**	NaN_3-NH_4ClO_4-$Mg(ClO_4)_2$ 2.5 M	MeCN	90	10	89
20	**36** R_1=Tr	NaN_3-NH_4Cl	MeOH-H_2O	59	41	92
21	**36**	NaN_3-NH_4ClO_4-$LiClO_4$ 5M	MeCN	80	20	86

All the reactions were carried out at 80°C for 18 h.

The azidolysis under chelating conditions of these diprotected cis **30-32** and trans **34-36** epoxides interestingly shows that the protective group introduced has a consistent effect on the regioselectivity result. A more pronounced, and synthetically useful, C-2 selectivity (80-90%) is obtained with the epoxides **32**, **35** and **36** (entries 10, 19, and 21, Table 2) as a consequence of an increased preference for the chelate bidentate species **75** (from the cis epoxide **32**) and **76** (from the trans epoxides **35** and **36**) (R_1= corresponding protective group, Scheme 5) which, in accordance with expectations, preferentially involves the OBn functionality.

In order to differentiate more consistently the coordinating ability of the two functionalities in a difunctionalized oxirane system, and in order to assemble, as far as possible, in a simple substrate all the information we had previously obtained, we decided to examine the regiochemical behavior of the trans epoxides **48-50** and **51** (Schemes 3 and 6) derived from trans 2-penten-1,5-diol. In these epoxides, the unsymmetrical disposition (allylic and homoallylic) of the two ether functionalities together with the favoring

Scheme 6



(Bn[4-6] and PMB group) or disfavoring effect (TBDMS and TIPS group)[15] of the protective group in determining the coordination ability of the linked oxygen, could be of crucial importance in selecting the formation of one of the two possible chelate species **87** or **88** (R_1 and R_2= corresponding protective group, Scheme 6) in the metal salt-promoted azidolysis, and, consequently, C-3 or C-2 selectivity, respectively.

The results obtained in the azidolysis opening reaction of epoxides **48-50** (BnO group is the homoallylic heterofunctionality) indicate that under standard conditions, *C-3 products* prevail (67-85%, Table 3), as expected on the basis of the inductive electron-withdrawing effect of the closer allylic OR_1 functionality (Scheme 6). Under chelating conditions, when $LiClO_4$ is used as the metal salt, an increase in C-3 selectivity is generally observed (88-99 %, Table 3), indicating the preferential formation of the chelate bidentate species **87**

(Scheme 6), independently of the nature of the allylic protective group. In this sense, the best result is obtained with epoxide **48** (R_1=Bn) where an interesting complete C-3 selectivity is obtained (entry 2, Table 3). On the contrary, the use of $Mg(ClO_4)_2$, as the promoting metal salt, has a dramatic, unexpected effect on the regioselectivity of epoxides **48-50** determining an increase in C-2 selectivity, which is moderate, even significant, in the case of epoxide **49** (entry 6, Table 3), but is really substantial in the case of epoxides **48** and **50**, where an inversion of the regioselectivity is obtained (*C-2/C-3 product*=60:40, entries 3 and 9, Table 3) thus making *C-2 products* from these systems synthetically more accessible. The results obtained with $Mg(ClO_4)_2$ indicate, under these operating conditions, the preferential formation in the reaction medium of the

Table 3. Regioselectivity of the Azidolysis of the Epoxides trans 48-51.

entry	epoxide	reagents	solvent	*C-2 product*	*C-3 product*	yield %
1	**48** R_1=Bn	NaN_3-NH_4Cl	MeOH-H_2O	15	85	90
2	**48**	NaN_3-$LiClO_4$ 5M	MeCN	<1	>99	87
3	**48**	NaN_3-$Mg(ClO_4)_2$ 2.5M	MeCN	60	40	88
4	**49** R_1=PMB	NaN_3-NH_4Cl	MeOH-H_2O	16	84	95
5	**49**	NaN_3-$LiClO_4$ 5M	MeCN	8	92	89
6	**49**	NaN_3-$Mg(ClO_4)_2$ 2.5M	MeCN	21	79	91
7	**50** R_1=TIPS	NaN_3-NH_4Cl	MeOH-H_2O	33	67	91
8	**50**	NaN_3-$LiClO_4$ 5M	MeCN	12	88	88
9	**50**	NaN_3-$Mg(ClO_4)_2$ 2.5M	MeCN	60	40	91
10	**51** R_1=Bn	NaN_3-NH_4Cl	MeOH-H_2O	23	77	82
11	**51**	NaN_3-$LiClO_4$ 5M	MeCN	10	90	85
12	**51**	NaN_3-$Mg(ClO_4)_2$ 2.5M	MeCN	3	97	88

All the reactions were carried out at 80°C for 18 h.

chelate bidentate species **88** (Scheme 6), in which the homoallylic OBn functionality is involved. The different behavior of $LiClO_4$ and $Mg(ClO_4)_2$ in generating the corresponding preferential chelate bidentate species (**87** or **88**) could be rationalized on the basis of a different steric demand of the metallic species involved in the coordination process. Following this rationale, whereas the smaller, at least in solution, Li^+ is efficaciously located in the five-membered ring of the chelate structure **87**, which implies the intervention of the allylic *O*-R_1 functionality, the large Mg^{++} is more favorably located in the six-membered ring of the chelate species **88**, which implies the incursion of the homoallylic OBn functionality. However, when the oxygen of the homoallylic functionality is less prone to coordination, as a consequence of the presence of the TBDMS group (epoxide **51**, Schemes 3 and 6), the use of the $Mg(ClO_4)_2$ as the promoting metal salt is not any more able to determine the preferential formation of the chelate bidentate species **88**. In this case an almost complete C-3 selectivity is observed, pointing to a preferential formation of the regioisomeric chelate bidentate species **87**, as in the case of the corresponding $LiClO_4$-promoted azidolysis (entries 11 and 12, Table 3).

In conclusion, the use of appropriate protective groups can determine in some cases the obtainment of satisfactory level of regioselectivity in the azidolysis of both mono- and difunctionalized aliphatic oxirane systems bearing the heterofunctionality (OR) in an homoallylic and/or allylic relationship to the oxirane ring. Moreover, in some cases, the use in the metal salt-promoted azidolysis[4] of an appropriate metal species (Mg^{++} or Li^{+}) can make it possible to obtain a nice, even if partial, regioalternating process.[4g-i]

Experimental

IR spectra for the comparison of compounds were taken with a Mattson 3000 FTIR spectrometer. ^1H NMR spectra were determined with a Varian EM 360 and/or a Bruker AC 200 spectrometer. The double resonance experiments were carried out on the monoacetyl or diacetyl derivatives of the primary addition products, the azido alcohols (see Schemes 4-6), as follows: a) in the monoacetyl derivatives of *C-3* and *C-4 products* from epoxides **13-19** (Scheme 4), the proton α to the acetyl group was irradiated, looking at significant changes of the signal of the C(2) protons, identified in the spectrum by irradiating the protons α to the OBn group; b) in the diacetates **71** and **73**, corresponding to *C-2 products* from epoxides **29-36**, and **72** and **74**, corresponding to *C-3 products* from the same epoxides (Scheme 5), the well-separated and easily distinguishable methylene protons α to the acetyl groups were irradiated, looking at significant changes of the signal of the methine proton α to the acetyl group, and vice versa; c) in the *C-2* and *C-3 products* from epoxides **48-51** (Scheme 6), the protons α to the acetyl group were irradiated, looking at significant changes in the aliphatic or $-OCH_2-$ region of the spectrum. GC analyses of mixtures of azido alcohols **55** and **56** (R_1=*t*-Bu) (column 140°C), **53** and **54**, **55** and **56** (R_1=Bn), **63** and **64** (R_1=TBDMS and TIPS), acetates **67** and **68** (R_1=TIPS), diacetates **71-74** (column 210°C) were performed on a Perkin-Elmer 8420 apparatus (FI detector) with a 30 m x 0.25 mm (i.d.) x 0.25 μm DB-WAX fused silica capillary column. The order of increasing retention times was **54**<**53**, **56**<**55** (R_1=Bn and *t*-Bu), **64**<**63** (R_1=TBDMS), **63**<**64** and **67**<**68** (R_1=TIPS), **71**<**72**, and **73**<**74**. In all cases, the injector and detector temperature was 250°C and a 2 ml/min nitrogen flow rate was employed. Preparative and semipreparative TLC were performed on a 2- and 0.5-mm Macherey-Nagel DC-Fertigplatten UV_{254} silica gel plates, respectively. Procedure for the acetylation reaction: a solution of the product (0.050 g) in anhydrous pyridine (2.0 ml) was treated with Ac_2O (1.0 ml) and the resulting reaction mixture was left 20 h at r.t. Toluene (10 ml) was added and the resulting solution was carefully evaporated to dryness under reduced pressure (rotating evaporator: this procedure was commonly repeated several times) to give a crude reaction product consisting of the corresponding acetylated derivative. General procedure for the transformation of acetates **67-70** (R_1=TBDMS, TIPS, Tr) into diacetates **71-74** (Scheme 5): a solution of the acetate **67-70** (R_1=TBDMS, TIPS, Tr) (0.050 g) in a 3:1:1 mixture of AcOH, H_2O and THF (5.0 ml) was left 20 h at r.t. Dilution with saturated aqueous NaCl, extraction with ether and evaporation of the washed (saturated aqueous $NaHCO_3$, and saturated aqueous NaCl) afforded a crude reaction product consisting of the corresponding diacetate **71-74** (GC and ^1H NMR). Alcohol **38**, aldehyde **40** and ester **42** were prepared as previously described.[9]

Benzylation of Alcohols 7, 8, 43, and 44. General Procedure. A solution of the alcohol (20.0 mmol) in anhydrous THF (25 ml) was added at 50°C to a stirred suspension of NaH (1.61 g of an 80%

dispersion in mineral oil, 53.7 mmol) and benzyl bromide (3.76 g, 22.0 mmol) in anhydrous THF (65 ml) and the resulting reaction mixture was stirred for 18 h at 55-60°C. After cooling, water was added in order to destroy the excess of the hydride. Dilution with ether (200 ml) and evaporation of the washed (water) organic solution afforded a crude reaction product consisting of the corresponding *O*-benzyl derivative which was purified by filtration on a short silica gel column. Elution with a 95:5 mixture of petroleum ether and ether afforded the pure benzylether (GC and ^{1}H NMR).

cis-1-(Benzyloxy)-3-hexene (9) (2.60 g), a liquid: ^{1}H NMR (60 MHz) ($CDCl_3$) δ 7.24-7.50 (m, 5H, aromatic protons), 5.43-5.71 (m, 2H, olefinic protons), 4.56 (s, 2H, CH_2Ph), 3.53 (t, 2H, *J*=6.8 Hz, CH_2O), 1.93-2.56 (m, 4H), 0.93 (t, 3H, *J*=7.2 Hz, CH_3). Anal.Calcd for $C_{13}H_{18}O$: C, 82.06; H, 9.53. Found: C, 82.17; H, 9.71.

trans-1-(Benzyloxy)-3-hexene (10) (2.75 g), a liquid: b.p. 79°C (0.3 mmHg); ^{1}H NMR (60 MHz) ($CDCl_3$) δ 7.25-7.50 (m, 5H, aromatic protons), 5.42-5.73 (m, 2H, olefinic protons), 4.58 (s, 2H, CH_2Ph), 3.52 (t, 2H, *J*=6.7Hz, CH_2O), 1.90-2.52 (m, 4H), 1.00 (t, 3H, *J*=7.2 Hz, CH_3). Anal.Calcd for $C_{13}H_{18}O$: C, 82.06; H, 9.53. Found: C, 82.39; H, 9.27.

trans-1,5-(Dibenzyloxy)-2-pentene (45) (5.20 g), a liquid: ^{1}H NMR (60 MHz) ($CDCl_3$) δ 7.40-7.68 (m, 10H, aromatic protons), 5.71-5.90 (m, 2H, olefinic protons), 4.56 (s, 4H, 2 CH_2Ph), 4.05-4.20 (m, 2H, CH_2O), 3.41-3.84 (m, 2H, CH_2O), 2.33-2.68 (m, 2H). Anal.Calcd for $C_{19}H_{22}O_2$: C, 80.82; H, 7.85. Found: C, 80.97; H, 8.01.

trans-1-(Benzyloxy)-5-(*t*-butyldimethylsilyloxy)-2-pentene (52) (7.80 g), a liquid: ^{1}H NMR ($CDCl_3$) δ 7.20-7.30 (m, 5H, aromatic protons), 5.56-5.80 (m, 2H, olefinic protons), 4.45 (s, 2H, CH_2Ph), 3.93 (d, 2H, *J*=4.8 Hz, CH_2OBn), 3.60 (t, 2H, *J*=6.8 Hz, CH_2OTBDMS), 2.24 (dd, 2H, *J*=12.6 and 6.8 Hz, CH_2-CH_2OTBDMS), 0.84 (s, 9H, *t*-Bu), 0.01 [s, 6H, $Si(CH_3)_2$]. Anal.Calcd for $C_{18}H_{30}O_2Si$: C, 70.53; H, 9.87. Found: C, 70.78; H, 9.59.

trans-1-(Benzyloxymethyloxy)-3-hexene (11). A solution of alcohol **8** (1.0 g, 10.0 mmol) in CH_2Cl_2 (30 ml) was treated with diisopropylethylamine (DIPEA) (2.65 ml) and freshly distilled benzyl chloromethyl ether (2.12 ml, 15.0 mmol)[13] and the reaction mixture was left for 18 h at r.t. Saturated acqueous NH_4Cl was added and the reaction mixture was extracted with ether. Evaporation of the organic solvent afforded a crude liquid product which was treated with MeOH (40 ml) and NEt_3 (0.85 ml) and the resulting solution was stirred at r.t. for 2.5 h and then concentrated. Dilution with ether and evaporation of the washed (water) organic solution afforded a crude liquid product (1.90 g) which was purified by filtration on a short silica gel column. Elution with a 75:25 mixture of petroleum ether and ether afforded pure ether **11** (1.4 g), as a liquid: ^{1}H NMR (60 MHz) ($CDCl_3$) δ 7.25-7.35 (m, 5H, aromatic protons), 5.16-5.46 (m, 2H, olefinic protons), 4.75 (s, 2H, OCH_2O), 4.60 (s, 2H, CH_2Ph), 3.70 (t, 2H, *J*=5.2 Hz, CH_2OBOM), 1.40-2.15 (m, 4H), 1.00 (t, 3H, *J*=7.3 Hz, CH_3). Anal.Calcd for $C_{14}H_{20}O_2$: C, 76.33; H, 9.15. Found: C, 76.20; H, 9.20.

trans-1-(*t*-Butoxy)-3-hexene (12). A solution of alcohol **8** (1.20 g, 12.0 mmol) in CH_2Cl_2 (30 ml) containing 98% H_2SO_4 (0.12 ml) was treated at -50°C with 2-methylpropene (25 ml) and the reaction mixture was stirred at the same temperature for 30 min, then for 18 h at r.t. Dilution with ether and evaporation of the washed (saturated aqueous $NaHCO_3$) organic solution afforded pure **12** (1.20 g), as a liquid: ^{1}H NMR (60 MHz) ($CDCl_3$) δ 5.16-5.46 (m, 2H, olefinic protons), 3.20 (t, 2H, *J*=6.4 Hz, CH_2O), 1.16-1.86 (m, 4H), 1.10 (s, 9H, *t*-Bu), 0.93 (t, 3H, *J*=7.2 Hz, CH_3). Anal.Calcd for $C_{10}H_{20}O$: C, 76.86; H, 12.90. Found: C, 76.71; H, 12.70.

trans-4-(Benzyloxy)-2-butenal (24). Following a previously described procedure,[8] the reaction of the cis olefin **20** (5.0 g, 28.0 mmol) in dry CH_2Cl_2 (50 ml) with a mixture of pyridinium chlorochromate (PCC) (12.15 g, 56.0 mmol) and celite (2.44 g) in CH_2Cl_2 (200 ml) afforded pure aldehyde **24** (2.3 g), as a liquid: IR ν 1691 cm^{-1}; ^1H NMR ($CDCl_3$) δ 9.47 (d, 1H, *J*=7.9 Hz, CHO), 7.25-7.27 (m, 5H, aromatic protons), 6.75 (dt, 1H, *J*=15.7 and 7.9 Hz, olefinic H_α), 6.13 (dd, 1H, *J*=15.7 and 3.9 Hz, olefinic H_β), 4.49 (s, 2H, CH_2Ph), 4.18 (dd, 2H, *J*=3.9 and 1.7 Hz, CH_2O). Anal.Calcd for $C_{11}H_{12}O_2$: C, 74.98; H, 6.86. Found: C, 74.70; H, 6.72.

trans-4-(Benzyloxy)-2-buten-1-ol (25). A stirred solution of the aldehyde **24** (1.70 g, 9.60 mmol) in MeOH (80 ml) was treated at -40°C with $NaBH_4$ (0.50 g, 13.5 mmol) and the resulting mixture was allowed to warm to -20°C and then stirred at this temperature for 2 h. Ice was added and stirring was prolonged for 30 min. After concentration of the solvent, dilution with CH_2Cl_2 and evaporation of the washed (saturated aqueous $NaHCO_3$) organic solution afforded pure **25** (1.55 g), as a liquid: ^1H NMR (60 MHz) ($CDCl_3$) δ 7.10-7.40 (m, 5H, aromatic protons), 5.67-5.90 (m, 2H, olefinic protons), 4.47 (s, 2H, CH_2Ph), 3.83-4.13 (m, 4H, 2 CH_2O). Anal.Calcd for $C_{11}H_{14}O_2$: C, 74.13; H, 7.92. Found: C, 74.35; H, 7.77.

Synthesis of Ethers 21-23, 26-28, and 47. General procedure. A solution of the cis **20** or trans **25** alcohol (2.50 g, 14.0 mmol) and imidazole (2.08 g, 30.8 mmol) in dry DMF (16 ml) [pyridine (14 ml) containing 4-*N,N*-dimethylaminopyridine (0.35 g, 2.8 mmol) in the case of the synthesis of **23** and **28**] was treated at 0°C with the appropriate chloride (*t*-butyldimethylsilyl chloride, triisopropyl chloride, or trityl chloride, 14.2 mmol) and the reaction mixture was stirred at the same temperature for 30 min then for 48 h at r.t. Dilution with hexane and evaporation of the washed (water) organic solution afforded a crude reaction product which was filtered on a short silica gel column (petroleum ether was used as the eluant) to give the corresponding pure ether.

cis-1-(Benzyloxy)-4-*t*-(butyldimethylsilyloxy)-2-butene (21) (4.1 g), a liquid: ^1H NMR ($CDCl_3$) δ 7.25-7.35 (m, 5H, aromatic protons), 5.60-5.77 (m, 2H, olefinic protons), 4.50 (s, 2H, CH_2Ph), 4.21 (d, 2H, *J*=4.8 Hz, CH_2O), 4.07 (d, 2H, *J*=5.0 Hz, CH_2O), 0.89 (s, 9H, *t*-Bu), 0.05 [s, 6H, $Si(CH_3)_2$]. Anal.Calcd for $C_{17}H_{28}O_2Si$: C, 69.81; H, 9.65. Found: C, 69.89; H, 9.51.

cis-1-(Benzyloxy)-4-(triisopropylsilyloxy)-2-butene (22) (3.0 g), a liquid: ^1H NMR ($CDCl_3$) δ 7.24-7.35 (m, 5H, aromatic protons), 5.56-5.81 (m, 2H, olefinic protons), 4.50 (s, 2H, CH_2Ph), 4.28 (dd, 2H, *J*=1.0 and 5.2 Hz, CH_2O), 4.07 (d, 2H, *J*=5.9 Hz, CH_2O), 0.97-1.09 [m, 21H, 3 Si $CH(CH_3)_2$]. Anal.Calcd for $C_{20}H_{34}O_2Si$: C, 71.80; H, 10.24. Found: C, 71.64; H, 10.12.

cis-1-(Benzyloxy)-4-(trityloxy)-2-butene (23) (3.20 g), a liquid: ^1H NMR ($CDCl_3$) δ 7.10-7.46 (m, 20H, aromatic protons), 5.64-5.91 (m, 2H, olefinic protons), 4.39 (s, 2H, CH_2Ph), 3.91 (d, 2H, *J*=6.4 Hz, CH_2O), 3.66 (d, 2H, *J*=5.92 Hz, CH_2O). Anal.Calcd for $C_{30}H_{28}O_2$: C, 85.68; H, 6.71. Found: C, 85.40; H, 6.52.

trans-1-(Benzyloxy)-4-*t*-(butyldimethylsilyloxy)-2-butene (26) (4.20 g), a liquid: ^1H NMR ($CDCl_3$) δ 7.27-7.48 (m, 5H, aromatic protons), 5.86-5.90 (m, 2H, olefinic protons), 4.53 (s, 2H, CH_2Ph), 4.15-4.21 (m, 2H, CH_2O), 4.02-4.11 (m, 2H, CH_2O), 0.91 (s, 9H, *t*-Bu), 0.09 [s, 6H, $Si(CH_3)_2$]. Anal.Calcd for $C_{17}H_{28}O_2Si$: C, 62.81; H, 9.65. Found: C, 69.69; H, 9.42.

trans-1-(Benzyloxy)-4-(triisopropylsilyloxy)-2-butene (27) (3.90 g), a liquid: ^{1}H NMR ($CDCl_3$) δ 7.31-7.44 (m, 5H, aromatic protons), 5.84-5.88 (m, 2H, olefinic protons), 4.52 (s, 2H, C*H*$_2$Ph), 4.23-4.33 (m, 2H, CH_2O), 4.05 (dd, 2H, *J*=3.1 and 1.1 Hz, CH_2O), 1.36-1.05 [m, 21H, 3 $CH(CH_3)_2$]. Anal.Calcd for $C_{20}H_{34}O_2Si$: C, 71.80; H, 10.24. Found: C, 71.96; H, 10.01.

trans-1-(Benzyloxy)-4-(trityloxy)-2-butene (28) (3.40 g), a liquid: ^{1}H NMR ($CDCl_3$) δ 7.17-7.51 (m, 20H, aromatic protons), 5.77-6.06 (m, 2H, olefinic protons), 4.53 (s, 2H, C*H*$_2$Ph), 4.06 (dd, 2H, *J*=5.3 and 0.7 Hz, CH_2O), 3.63 (dd, 2H, *J*=4.5 and 1.1 Hz, CH_2O). Anal.Calcd for $C_{30}H_{28}O_2$: C, 85.68; H, 6.71. Found: C, 85.41; H, 6.49.

trans-5-(Benzyloxy)-1-(triisopropylsilyloxy)-2-pentene (47) (3.38 g), a liquid: ^{1}H NMR ($CDCl_3$) δ 7.17-7.28 (m, 5H, aromatic protons), 5.49-5.72 (m, 2H, olefinic protons), 4.44 (s, 2H, C*H*$_2$Ph), 4.13 (d, 2H, *J*=3.5 Hz, CH_2O), 3.44 (t, 2H, *J*=6.8 Hz, CH_2O), 2.25-2.35 (m, 2H), 0.93-1.06 (m, 21H, 3 $CH(CH_3)_2$]. Anal.Calcd for $C_{21}H_{36}O_2Si$: C, 72.36; H, 10.41. Found: C, 72.18; H, 10.38.

3-(Benzyloxy)-1-propanol (37). A solution of 1,3-propandiol (36.48 g, 0.48 mol) in anhydrous THF (100 ml) was added at r.t. to a stirred suspension of NaH (7.2 g of an 80% dispersion in mineral oil, 0.24 mol) in anhydrous THF (400 ml) and the reaction mixture was stirred for 2 h at the same temperature. A solution of benzyl bromide (27.44 g, 0.16 mol) in anhydrous THF (50 ml) was slowly added and the reaction mixture was stirred for 18 h at 50°C. After cooling, dilution with ether and evaporation of the washed (water) organic solution afforded a crude reaction product (23.2 g) which was purified by filtration on a short silica gel column. Elution with a 9:1 mixture of petroleum ether and AcOEt afforded pure **37** (12.9 g), as a liquid: ^{1}H NMR (60 MHz) ($CDCl_3$) δ 7.25-7.40 (m, 5H, aromatic protons), 4.56 (s, 2H, C*H*$_2$Ph), 3.36-3.93 (m, 4H, 2 CH_2O), 1.66-2.06 (m, 2H). Anal.Calcd for $C_{10}H_{14}O_2$: C, 72.26; H, 8.49. Found: C, 72.12; H, 8.32.

3-(Benzyloxy)propanal (39). A solution of **37** (6.74 g, 40.63 mmol) in anhydrous CH_2Cl_2 (170 ml) was treated, under stirring, at 0°C with PCC (18.12 g, 84.17 mmol), added in three portions. The reaction mixture was stirred at r.t. for 2.5 h, then diluted with anhydrous ether (420 ml): after 5 min stirring, the organic solution was filtered through a short silica gel-Florisil column. Evaporation of the washed (aqueous NaOH 10%, and saturated aqueous NaCl) organic solution afforded a liquid product (5.95 g) consisting of the aldehyde **39**, practically pure, which was directly used in the next step without any further purification: IR ν 1728 cm^{-1}; ^{1}H NMR (60 MHz) ($CDCl_3$) δ 9.80-10.0 (m, 1H, CHO), 7.30-7.50 (m, 5H, aromatic protons), 4.56 (s, 2H, C*H*$_2$Ph), 3.86 (t, 2H, *J*=6.0 Hz, CH_2O), 2.56-2.90 (m, 2H). Anal.Calcd for $C_{10}H_{12}O_2$: C, 73.15; H, 7.37. Found: C, 73.22; H, 7.63.

Ethyl-5-(benzyloxy)-2-pentenoate (41). A stirred suspension of NaH (1.57 g of an 80% dispersion in mineral oil, 52.5 mmol) in anhydrous THF (80 ml) was treated at 0°C with triethylphosphonoacetate (TEPA) (12.0 g, 53.4 mmol) added over 20 min. After 40 min at the same temperature, the reaction mixture was cooled at -78°C and a solution of aldehyde **39** (5.95 g, 36.31 mmol) in anhydrous THF (20 ml) was dropwise added in 30 min. The reaction mixture was stirred at 0°C for 30 min, then ether and saturated aqueous NH_4Cl (20 ml) were added. Evaporation of the washed (water) organic solution afforded a crude reaction product which was taken up in hexane; evaporation of the washed (water) hexane solution afforded a crude liquid product (7.30 g) which was purified by filtration through a short silica gel column. Elution with a 95:5 mixture of petroleum ether and ether afforded pure ester **41** (6.80 g): IR ν 1720 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.25-7.35 (m, 5H, aromatic protons), 6.98 (dt, 1H, *J*=15.7 and 6.9 Hz, olefinic H_α), 5.89 (dt, 1H, *J*=15.7 and 1.5 Hz, olefinic H_β), 4.52 (s, 2H, C*H*$_2$Ph), 4.19 (q, 2H, *J*=4.5 Hz,

OCH_2CH_3), 3.53-3.61 (m, 2H, CH_2O), 2.51 (ddd, 2H, J=6.5 and 1.4 Hz, CH_2CH_2O), 1.28 (t, 3H, J=7.2 Hz, CH_3). Anal.Calcd for $C_{14}H_{18}O_3$: C, 71.77; H, 7.74. Found: C, 71.58; H, 7.56.

trans-5-(Benzyloxy)-2-penten-1-ol (43). A solution of the ester **41** (7.30 g, 31.17 mmol) in anhydrous ether (200 ml) was treated under nitrogen at -20°C with a 1M DIBAL solution in cyclohexane (62.3 ml) and the reaction mixture was stirred 30 min at the same temperature then allowed to warm to r.t., and quenched with MeOH (3.5 ml) and water (4.0 ml). Evaporation of the washed (5% aqueous HCl, and water) combined ether extracts afforded a crude liquid product (5.10 g) consisting of **43**, practically pure, which was used in the next step without any further purification: ^1H NMR ($CDCl_3$) δ 7.25-7.35 (m, 5H, aromatic protons), 5.69-5.74 (m, 2H, olefinic protons), 4.51 (s, 2H, CH_2Ph), 4.07-4.10 (m, 2H, CH_2OH), 3.52 (t, 2H, J=6.6 Hz, CH_2OBn), 2.32-2.42 (m, 2H). Anal.Calcd for $C_{12}H_{16}O_2$: C, 74.97; H, 8.39. Found: C, 74.71; H, 8.18.

trans-5-(*t*-Butyldimethylsilyloxy)-2-penten-1-ol (44). Proceeding as described above for the preparation of alcohol **43**, the reaction of ester **42**[9] (5.87 g, 22.78 mmol) in anhydrous ether (150 ml) with a 1M DIBAL solution in cyclohexane (46.67 ml) gave a reaction mixture which was quenched with EtOH (1.7 ml) and saturated aqueous Na_2SO_4 (2.2 ml), while stirring was maintained for 10 min. Dilution with ether (100 ml) gave a suspension which was stirred for 18 h at r.t.. Filtration of the washed (ether) gelatinous solid and evaporation of the organic solution afforded a crude liquid product (4.32 g) consisting of **44**, practically pure, which was used in the next step without any further purification: ^1H NMR ($CDCl_3$) δ 5.73-5.78 (m, 2H, olefinic protons), 4.05-4.21 (m, 2H, CH_2OH), 3.75 (t, 2H, J=6.8 Hz, CH_2O), 2.29 (dt, 2H, J=6.8 and 6.0 Hz), 0.93 (s, 9H, *t*-Bu), 0.01 [s, 6H, $Si(CH_3)_2$]. Anal.Calcd for $C_{11}H_{24}O_2Si$: C, 61.06; H, 11.18. Found: C, 59.83; H, 11.04.

trans-5-(Benzyloxy)-1-(*p*-methoxybenzyloxy)-2-pentene (46). A solution of alcohol **43** (1.00 g, 5.2 mmol) in anhydrous THF (5 ml) was added to a stirred suspension of NaH (0.31 g of an 80% dispersion in mineral oil, 10.4 mmol) in anhydrous THF (20 ml) containing *p*-methoxybenzylchloride (PMBCl) (0.84 g, 5.4 mmol) and the reaction mixture was stirred for 18 h at 45-50°C. After cooling, water was added in order to destroy the excess of hydride: dilution with ether and evaporation of the washed (water) organic solution afforded a crude reaction product (1.22 g) which was purified by filtration on a short silica gel column. Elution with a 95:5 mixture of petroleum ether and ether afforded pure **46** (0.65 g), as a liquid: ^1H NMR (60 MHz) ($CDCl_3$) δ 6.70-7.53 (m, 9H, aromatic protons), 5.60-5.86 (m, 2H, olefinic protons), 4.26-4.60 (m, 4H, CH_2OCH_2), 3.33-4.06 (m, 5H, OCH_3 and CH_2OBn), 2.13-2.56 (m, 2H). Anal.Calcd for $C_{20}H_{24}O_3$: C, 76.89; H, 7.74. Found: C, 76.71; H, 7.56.

Synthesis of the Epoxides 13-16, 18, 29-36, and 48-51. General procedure. A solution of the olefin [**8-12**, **20-23**, **25-28**, **45-47** and **52** (15.0 mmol)] in CH_2Cl_2 (120 ml) was treated at 0°C with 55% MCPBA (5.15 g, 16.4 mmol) and the resulting reaction mixture was stirred at 0-5°C until the olefin was completely reacted (TLC). 5% Aqueous $Na_2S_2O_3$ (20 ml) was added and the reaction mixture was stirred for 20 min. Dilution with CH_2Cl_2 (200 ml) and evaporation of the washed (saturated aqueous $NaHCO_3$, 5% aqueous NaOH, and water) organic solution afforded a crude reaction product consisting of the corresponding epoxide, practically pure.

cis-1-(Benzyloxy)-3,4-epoxyhexane (13), a liquid: ^1H NMR ($CDCl_3$) δ 7.30-7.36 (m, 5H, aromatic protons), 4.54 (s, 2H, CH_2Ph), 3.64 (t, 2H, J=6.8 Hz, CH_2OBn), 3.05-3.13 (m, 1H, oxirane proton), 2.86-2.95 (m, 1H, oxirane proton), 1.71-1.96 (m, 2H, CH_2CH_2O), 1.46-1.58 (m, 2H, CH_2CH_3), 1.03 (t, 3H, J=7.5 Hz, CH_3). Anal.Calcd for $C_{13}H_{18}O_2$: C, 75.69; H, 8.80. Found: C, 75.51; H, 8.56.

trans-3,4-Epoxy-1-hexanol (14), a liquid: ^1H NMR ($CDCl_3$) δ 3.65 (t, 2H, J=6.7 Hz, -CH_2O), 2.76-2.83 (m, 1H, oxirane proton), 2.65-2.72 (m, 1H, oxirane proton), 1.77-1.88 (m, 2H, CH_2CH_2O), 1.42-1.75 (m, 2H, CH_2CH_3), 0.91 (t, 3H, J=7.4 Hz, CH_3). Anal.Calcd for $C_6H_{12}O_2$: C, 62.04; H, 10.41. Found: C, 62.18; H, 10.49.

trans-1-(Benzyloxy)-3,4-epoxyhexane (15), a liquid: ^1H NMR ($CDCl_3$) δ 7.29-7.38 (m, 5H, aromatic protons), 4.53 (s, 2H, CH_2Ph), 3.61 (t, 2H, J=6.5 Hz, CH_2O), 2.81-2.92 (m, 1H, oxirane proton), 2.68-2.74 (m, 1H, oxirane proton), 1.71-1.92 (m, 2H, CH_2CH_2O), 1.50-1.64 (m, 2H, CH_2CH_3), 0.98 (t, 3H, J=7.5 Hz, CH_3). Anal.Calcd for $C_{13}H_{18}O_2$: C, 75.69; H, 8.80. Found: C, 75.79; H, 8.49.

trans-1-(Benzyloxymethyl)-3,4-epoxyhexane (16), a liquid: ^1H NMR ($CDCl_3$) δ 7.25-7.37 (m, 5H, aromatic protons), 4.78 (s, 2H, OCH_2OBn), 4.61 (s, 2H, CH_2Ph), 3.72 (t, 2H, J=5.9 Hz, CH_2OBOM), 2.80-2.87 (m, 1H, oxirane proton), 2.69-2.75 (m, 1H, oxirane proton), 1.72-1.96 (m, 2H, CH_2CH_2O), 1.51-1.69 (m, 2H, CH_2CH_3), 0.99 (t, 3H, J=7.5 Hz, CH_3). Anal.Calcd for $C_{14}H_{20}O_3$: C, 71.16; H, 8.53. Found: C, 71.02; H, 8.64.

trans-1-(*t*-Butoxy)-3,4-epoxyhexane (18), a liquid: ^1H NMR ($CDCl_3$) δ 3.47 (t, 2H, J=5.9 Hz, CH_2O), 2.76-2.83 (m, 1H, oxirane proton), 2.64-2.71 (m, 1H, oxirane proton), 1.48-1.91 (m, 4H), 1.18 (s, 9H, *t*-Bu), 0.97 (t, 3H, J=7.5 Hz, CH_3). Anal.Calcd for $C_{10}H_{20}O_2$: C, 69.72; H, 11.70. Found: C, 69.49; H, 11.57.

cis-4-(Benzyloxy)-2,3-epoxy-1-butanol (29), a liquid: ^1H NMR ($CDCl_3$) δ 7.17-7.31 (m, 5H, aromatic protons), 4.48 (ABdd, 2H, J=11.8 Hz, CH_2Ph), 3.53-3.69 (m, 4H, 2 CH_2O), 3.07-3.22 (m, 2H, oxirane protons). Anal.Calcd for $C_{11}H_{14}O_3$: C, 68.02; H, 7.27. Found: C, 68.15; H, 7.39.

cis-1-(Benzyloxy)-4-(*t*-butyldimethylsilyloxy)-2,3-epoxybutane (30), a liquid: ^1H NMR ($CDCl_3$) δ 7.20-7.31 (m, 5H, aromatic protons), 4.52 (ABdd, 2H, J=11.9 Hz, -CH_2Ph), 3.72 (dd, 1H, J=4.6 and 11.8 Hz, one proton of CH_2O), 3.67 (dd, 1H, J=11.3 and 3.9 Hz, one proton of CH_2O), 3.63 (dd, 1H, J=11.8 and 5.7 Hz, one proton of CH_2O), 3.49 (dd, 1H, J=11.3 and 6.3 Hz, one proton of CH_2O), 3.20 (dt, 1H, J=6.4 and 4.2 Hz, oxirane proton), 3.05 (dt, 1H, J=5.7 and 4.5 Hz, oxirane proton), 0.83 (s, 9H, *t*-Bu), 0.05 [s, 6H, $Si(CH_3)_2$]. Anal.Calcd for $C_{17}H_{28}O_3Si$: C, 66.19; H, 9.15. Found: C, 66.38; H, 9.01.

cis-1-(Benzyloxy)-2,3-epoxy-4-(triisopropylsilyloxy)butane (31), a liquid: ^1H NMR ($CDCl_3$) δ 7.16-7.28 (m, 5H, aromatic protons), 4.50 (ABdd, 2H, J=11.9 Hz, CH_2Ph), 3.71-3.75 (m, 2H, CH_2O), 3.66 (dd, 1H, J=11.2 and 3.7 Hz, one proton of CH_2O), 3.47 (dd, 1H, J=11.2 and 6.2 Hz, one proton of CH_2O), 3.09-3.21 (m, 2H, oxirane protons), 0.97 (s, 21H, 3 $CH(CH_3)_2$]. Anal.Calcd for $C_{20}H_{34}O_3Si$: C, 68.52; H, 9.78. Found: C, 68.31; H, 9.60.

cis-1-(Benzyloxy)-2,3-epoxy-4-(trityloxy)butane (32), a liquid: ^1H NMR ($CDCl_3$) δ 7.06-7.36 (m, 20 H, aromatic protons), 4.35 (ABdd, 2H, J=11.9 Hz, CH_2Ph), 2.99-3.48 (m, 6H, 2 CH_2O and oxirane protons). Anal.Calcd for $C_{30}H_{28}O_3$: C, 82.54; H, 6.46. Found: C, 82.61; H, 6.51.

trans-4-(Benzyloxy)-2,3-epoxy-1-butanol (33), a liquid: ^1H NMR ($CDCl_3$) δ 7.10-7.23 (m, 5H, aromatic protons), 4.41 (s, 2H, CH_2Ph), 3.62-3.75 (m, 2H, CH_2O), 3.35-3.48 (m, 2H, CH_2O), 3.06 (dt, 1H, J=2.5 and 5.4 Hz, oxirane proton), 2.91 (dt, 1H, J=4.8 and 2.5 Hz, oxirane proton). Anal.Calcd for $C_{11}H_{14}O_3$: C, 68.02; H, 7.27. Found: C, 68.34; H, 7.55.

trans-1-(Benzyloxy)-4-(*t*-butyldimethylsilyloxy)-2,3-epoxybutane (**34**), a liquid: ^{1}H NMR ($CDCl_3$) δ 7.17-7.29 (m, 5H, aromatic protons), 4.51 (ABdd, 2H, *J*=12.1 Hz, CH_2Ph), 3.38-3.84 (m, 4H, 2 CH_2O), 3.06 (dt, 1H, *J*=5.4 and 2.5 Hz, oxirane proton), 2.92 -2.97 (m, 1H, oxirane proton), 0.83 (s, 9H, *t*-Bu), 0.03 [s, 6H, $Si(CH_3)_2$]. Anal.Calcd for $C_{17}H_{28}O_3Si$: C, 66.19; H, 9.15. Found: C, 66.40; H, 8.95.

trans-1-(Benzyloxy)-2,3-epoxy-4-(triisopropylsilyloxy)butane (**35**), a liquid: ^{1}H NMR ($CDCl_3$) δ 7.20-7.28 (m, 5H, aromatic protons), 4.51 (ABdd, 2H, *J*=12.0 Hz, CH_2Ph), 3.38-3.90 (m, 4H, 2 CH_2O), 3.10 (dt, 1H, *J*=5.3 and 2.5 Hz, oxirane proton), 2.92-3.04 (m, 1H, oxirane proton), 1.01 (s, 21 H, 3 $CH(CH_3)_2$]. Anal.Calcd for $C_{20}H_{34}O_3Si$: C, 68.52; H, 9.78. Found: C, 68.49; H, 9.98.

trans-1-(Benzyloxy)-2,3-epoxy-4-(trityloxy)butane (**36**), a liquid: ^{1}H NMR ($CDCl_3$) δ 7.08-7.38 (m, 20H, aromatic protons), 4.47 (ABdd, 2H, *J*=12.0 Hz, CH_2Ph), 3.63 (dd, 1H, *J*=11.5 and 2.9 Hz, one proton of CH_2O), 3.36 (dd, 1H, *J*=11.5 and 5.7 Hz, one proton of CH_2O), 3.24 (dd, 2H, *J*=10.5 and 2.4 Hz, CH_2O), 2.96-3.08 (m, 2H, oxirane protons). Anal.Calcd for $C_{30}H_{28}O_3$: C, 82.54; H, 6.46. Found: C, 82.39; H, 6.36.

trans-1,5-(Dibenzyloxy)-2,3-epoxypentane (**48**), a liquid: ^{1}H NMR ($CDCl_3$) δ 7.17-7.29 (m, 10H, aromatic protons), 4.47 (s, 2H, CH_2Ph), 3.68 (dd, 1H, *J*=11.5 and 3.0 Hz, one proton of CH_2O), 3.55 (ddd, 2H, *J*=6.5 and 2.5 Hz, CH_2O), 3.41 (dd, 1H, *J*=11.5 and 5.6 Hz, one proton of CH_2O), 2.91-2.99 (m, 2H, oxirane protons), 1.72-1.95 (m, 2H). Anal.Calcd for $C_{19}H_{22}O_3$: C, 76.48; H, 7.43. Found: C, 76.51; H, 7.21.

trans-5-(Benzyloxy)-2,3-epoxy-1-(*p*-methoxybenzyloxy)pentane (**49**), a liquid: ^{1}H NMR (60 MHz) ($CDCl_3$) δ 6.83-7.43 (m, 9H, aromatic protons), 4.33-4.56 (m, 4H, CH_2Ph and CH_2Ar), 3.40-3.86 (m, 7H, OCH_3 and 2 CH_2O), 2.73-3.06 (m, 2H, oxirane protons), 1.33-1.53 (m, 2H). Anal.Calcd for $C_{20}H_{24}O_4$: C, 73.15; H, 7.37. Found: C, 73.22; H, 7.31.

trans-5-(Benzyloxy)-2,3-epoxy-1-(triisopropylsilyloxy)pentane (**50**), a liquid : ^{1}H NMR ($CDCl_3$) δ 7.22-7.34 (m, 5H, aromatic protons), 4.51 (s, 2H, CH_2Ph), 3.89 (dd, 1H, *J*=11.6 and 3.3 Hz, one proton of CH_2O), 3.73 (dd, 1H, *J*=11.6 and 4.7 Hz, one proton of CH_2O), 3.60 (dt, 2H, *J*=6.3 and 1.7 Hz, CH_2O), 3.00-3.07 (m, 1H, oxirane proton), 2.91-2.96 (m, 1H, oxirane proton), 1.72-2.00 (m, 2H), 0.92-1.06 [m, 21H, 3 $CH(CH_3)_2$}. Anal.Calcd for $C_{21}H_{36}O_3Si$: C, 69.18; H, 9.95. Found: C, 69.23; H, 9.81.

trans-1-(Benzyloxy)-5-(*t*-butyldimethylsilyloxy)-2,3-epoxypentane (**51**), a liquid: ^{1}H NMR ($CDCl_3$) δ 7.30-7.36 (m, 5H, aromatic protons), 4.57 (ABdd, 2H, *J*=12.0 Hz, CH_2Ph), 3.71-3.78 (m, 3H, three protons of 2 CH_2O), 3.45 (dd, 1H, *J*=11.3 and 5.4 Hz, one proton of CH_2O), 2.93-3.03 (m, 2H, oxirane protons), 1.58-1.77 (m, 2H), 0.82 (s, 9H, *t*-Bu), 0.06 [s, 6H, $Si(CH_3)_2$]. Anal.Calcd for $C_{18}H_{30}O_3Si$: C, 67.03; H, 9.38. Found: C, 67.21; H, 9.18.

trans-3,4-Epoxy-1-(*p*-methoxybenzyloxy)hexane (**17**). A solution of the trans epoxide **15** (1.16 g, 10.0 mmol) in anhydrous THF (14 ml) was slowly added to a stirred suspension of NaH (0.565 g of an 80% dispersion in mineral oil, 21.3 mmol) in anhydrous THF (40 ml) containing PMBCl (1.64 g, 10.47 mmol), and the resulting reaction mixture was stirred for 18 h at 45-50°C. The usual work-up afforded a crude reaction product which was purified by filtration through a short silica gel column. Elution with a 9:1 mixture of petroleum ether and ether afforded pure trans epoxide **17** (1.2 g), as a liquid: ^{1}H NMR ($CDCl_3$) δ 7.16-7.22 (m, 2H, aromatic protons), 6.78-6.83 (m, 2H, aromatic protons), 4.37 (s, 2H, CH_2Ph), 3.73 (s, 3H, OCH_3), 3.50 (t, 2H, *J*=6.4 Hz, CH_2O), 2.72-2.78 (m, 1H, oxirane proton), 2.59-2.65 (m, 1H, oxirane proton), 1.48-1.86 (m, 2H, CH_2CH_2O), 1.41-1.47 (m, 2H, CH_2CH_3), 0.90 (t, 3H, J=7.5 Hz, CH_3). Anal.Calcd for $C_{14}H_{20}O_3$: C, 71.16; H, 8.53. Found: C, 71.29; H, 8.61.

trans-1-Acetoxy-3,4-epoxyhexane (19). A solution of the trans epoxide **14** (1.5 g, 12.9 mmol) in anhydrous pyridine (8 ml) was treated at 0°C with Ac_2O (4 ml) and the resulting reaction mixture was stirred at r.t. for 18 h. The usual work-up afforded a crude liquid (1.65 g) consisting of epoxide **19** practically pure, as a liquid: ^{1}H NMR ($CDCl_3$) δ 4.15 (t, 2H, J=6.4 Hz, CH_2OAc), 2.70-2.75 (m, 1H, oxirane proton), 2.61-2.68 (m, 1H, oxirane proton), 2.01 (s, 3H, $COCH_3$), 1.68-1.91 (m, 2H, CH_2CH_2O), 1.42-1.61 (m, 2H, CH_2CH_3), 0.94 (t, 3H, J=7.5 Hz, CH_3). Anal.Calcd for $C_8H_{14}O_3$: C, 60.74; H, 8.92. Found: C, 60.95; H, 8.75.

Azidolysis of Epoxides 13-19, 29-36 and 48-51 with NaN_3-NH_4Cl. General Procedure. A solution of the epoxide (0.50 mmol) in an 8:1 MeOH/H_2O mixture (4.5 ml) was treated with NaN_3 (0.15 g, 2.3 mmol) and NH_4Cl (0.054 g, 1.0 mmol) and the resulting reaction mixture was stirred at 80°C for 18 h. Dilution with ether and evaporation of the washed (water) organic solution afforded a crude reaction product which was analyzed by GC and ^{1}H NMR to give the results shown in Tables 1-3.

The crude reaction product (0.117 g) from the cis epoxide **13** was purified by semipreparative TLC (an 8:2 mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the two most intense bands (the faster moving contained **54**) afforded pure azido alcohols **53** (0.025 g) and **54** (0.040 g).

syn-4-Azido-6-(benzyloxy)-3-hexanol (53), a liquid: IR ν 2101 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.19-7.31 (m, 5H, aromatic protons), 4.46 (s, 2H, CH_2Ph), 3.48-3.61 (m, 4H, CHOH, CHN_3, and -CH_2O), 1.85-2.04 (m, 2H, CH_2CH_2O), 1.51-1.72 (m, 2H, CH_2CH_3), 0.92 (t, 3H, J=7.3 Hz, CH_3). Anal.Calcd for $C_{13}H_{19}N_3O_2$: C, 62.63; H, 7.78; N, 16.85. Found: C, 62.80; H, 7.50; N, 16.61. **Acetate (57)**, a liquid: IR ν 2106, 1742 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.19-7.29 (m, 5H, aromatic protons), 4.83 (ddd, 1H, J=6.5 and 4.5 Hz, CHOAc), 4.45 (s, 2H, CH_2Ph), 3.50-3.56 (m, 3H, CHN_3 and CH_2O), 2.03 (s, 3H, $COCH_3$), 1.48-1.85 (m, 4H), 0.84 (t, 3H, J=7.4 Hz, CH_3). Anal.Calcd for $C_{15}H_{21}N_3O_3$: C, 61.84; H, 7.27; N, 14.42. Found: C, 61.72; H, 7.41; N, 14.50.

syn-4-Azido-1-(benzyloxy)-3-hexanol (54), a liquid: IR ν 2100 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.19-7.31 (m, 5H, aromatic protons), 4.46 (s, 2H, CH_2Ph), 3.77 (dt, 1H, J=9.2 and 3.4 Hz, CHOH), 3.62 (ddd, 2H, J=8.04, 5.8 and 4.6 Hz, CH_2O), 2.95-3.03 (m, 1H, CHN_3), 1.52-1.93 (m, 4H), 0.95 (t, 3H, J=7.3 Hz, CH_3). Anal.Calcd for $C_{13}H_{19}N_3O_2$: C, 62.63; H, 7.78; N, 16.85. Found: C, 62.49; H, 7.41; N, 16.70. **Acetate (58)**, a liquid: IR ν 1745, 2100 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.19-7.29 (m, 5H, aromatic protons), 5.11 (ddd, 1H, J=6.9, 5.9 and 3.9 Hz, CHOAc), 4.40 (s, 2H, CH_2Ph), 3.42 (ddd, 2H, J=14.6, 5.8 and 3.3 Hz, CH_2O), 3.17 (ddd, 1H, J=7.8, 6.0, and 3.9 Hz, CHN_3), 1.99 (s, 3H, $COCH_3$), 1.84-1.96 (m, 2H, CH_2CH_2O), 1.46-1.53 (m, 2H, CH_2CH_3), 0.94 (t, 3H, J=7.3 Hz, CH_3). Anal.Calcd for $C_{15}H_{21}N_3O_3$: C, 61.84; H, 7.27; N, 14.42. Found: C, 61.72; H, 7.38; N, 14.58.

The crude reaction product (0.111 g) from the trans epoxide **15** was purified by semiprepative TLC (a 9:1 mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **56**) afforded the pure azido alcohols **55** (0.030 g) and **56** (0.045 g) (R_1=Bn).

anti-4-Azido-6-(benzyloxy)-3-hexanol (**55**, R_1=Bn), a liquid: IR ν 2100 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.19-7.27 (m, 5H, aromatic protons), 4.46 (s, 2H, CH_2Ph), 3.48-3.61 (m, 4H), 1.75-1.90 (m, 2H, CH_2CH_2O), 1.42-1.55 (m, 2H, CH_2CH_3), 0.93 (t, 3H, J=7.3 Hz, CH_3). Anal.Calcd for $C_{13}H_{19}N_3O_2$:

C, 62.63; H, 7.78; N, 16.85. Found: C, 62.40; H, 7.81; N, 16.70. **Acetate** (**59**, R_1=Bn), a liquid: IR ν 2102, 1742 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.19-7.29 (m, 5H, aromatic protons), 4.86 (ddd, 1H, *J*=4.3 and 8.6 Hz, C*H*OAc), 3.66 (dt, 1H, *J*=4.3 and 10.5 Hz, CHN_3), 3.51 (dd, 2H, *J*=7.5 and 5.6 Hz, CH_2O), 2.03 (s, 3H, $COCH_3$), 1.71-1.83 (m, 2H, CH_2CH_2O), 1.47-1.63 (m, 2H, CH_2CH_3), 0.84 (t, 3H, *J*=7.4 Hz, CH_3). Anal.Calcd for $C_{15}H_{21}N_3O_3$: C, 61.84; H, 7.27; N, 14.42. Found: C, 61.70; H, 7.32; N, 14.20.

anti-4-Azido-1-(benzyloxy)-3-hexanol (**56**, R_1=Bn), a liquid: IR ν 2100 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.19-7.28 (m, 5H, aromatic protons), 4.46 (s, 2H, CH_2Ph), 3.54-3.80 (m, 3H, CH_2O and C*H*OH), 3.17-3.23 (ddd, 1H, *J*=9.2 and 4.5 Hz, CHN_3), 1.64-1.81 (m, 2H, CH_2CH_2O), 1.43-1.65 (m, 2H, CH_2CH_3), 0.96 (t, 3H, *J*=7.4 Hz, CH_3). Anal.Calcd for $C_{13}H_{19}N_3O_2$: C, 62.63; H, 7.78; N, 16.85. Found: C, 62.65; H, 7.72; N, 16.91. **Acetate** (**60**, R_1=Bn), a liquid: IR ν 2102, 1743 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.19-7.27 (m, 5H, aromatic protons), 5.07 (ddd, 1H, *J*=8.2 and 4.1 Hz, C*H*OAc), 4.40 (ABdd, 2H, *J*=11.9 Hz, CH_2Ph), 3.32-3.51 (m, 3H, CH_2O and CHN_3), 1.96 (s, 3H, $COCH_3$), 1.77-1.91 (m, 2H, CH_2CH_2O), 1.32-1.54 (m, 2H, CH_2CH_3), 0.95 (t, 3H, *J*=7.3 Hz, CH_3). Anal.Calcd for $C_{15}H_{21}N_3O_3$: C, 61.84; H, 7.27; N, 14.42. Found: C, 61.69; H, 7.38; N, 14.51.

The crude acetylated reaction product (0.124 g) from the trans epoxide **16** was purified by semipreparative TLC (an 8:2 mixture of petroleum ether and ether was used as the eluant). Extraction of the most intense band afforded pure **anti-3-acetoxy-4-azido-1-(benzyloxymethyloxy)hexane** (**60**, R_1=BOM) (0.050 g), as a liquid: IR ν 2104, 1743 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.19-7.27 (m, 5H, aromatic protons), 5.05 (dt, 1H, *J*=8.7 and 3.7 Hz, C*H*OAc), 4.65 (ABdd, 2H, *J*=6.8 Hz, CH_2OBn), 4.50 (s, 2H, CH_2Ph), 3.50-3.60 (m, 2H, CH_2O), 3.42 (ddd, 1H, *J*=8.7 and 3.9 Hz, CHN_3), 1.99 (s, 3H, $COCH_3$), 1.75-1.93 (m, 2H, CH_2CH_2O), 1.37-1.52 (m, 2H, CH_2CH_3), 0.96 (t, 3H, *J*=7.4 Hz, CH_3). Anal.Calcd for $C_{16}H_{23}N_3O_4$: C, 59.8; H, 7.21; N, 13.07. Found: C, 59.61; H, 7.42; N, 13.10.

Due to TLC separation problem, it was not possible to obtain the regioisomer **59** (R_1=BOM) pure. However, its presence in the crude reaction product was substantiated by GC and ^{1}H NMR evidence.

The crude reaction product (0.125 g) from the trans epoxide **17** was purified by semipreparative TLC (an 8:1:1 mixture of petroleum ether, AcOEt and diisopropyl ether was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **56**) afforded pure azido alcohols **55** (0.025 g) and **56** (0.057 g) (R_1=PMB).

anti-4-Azido-6-(*p*-methoxybenzyloxy)-3-hexanol (**55**, R_1=PMB), a liquid: IR ν 2101 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.16-7.20 (m, 2H, aromatic protons), 6.79-6.84 (m, 2H, aromatic protons), 4.38 (s, 2H, CH_2Ar), 3.73 (s, 3H, OCH_3), 3.43-3.61 (m, 4H), 1.68-1.84 (m, 2H, CH_2CH_2O), 1.33-1.57 (m, 2H, CH_2CH_3), 0.92 (t, 3H, *J*=7.3 Hz, CH_3). Anal.Calcd for $C_{14}H_{21}N_3O_3$: C, 60.20; H, 7.58; N, 15.04. Found: C, 59.85; H, 7.42; N, 15.21. **Acetate** (**59**, R_1=PMB), a liquid: IR ν 2106, 1742 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.25-7.30 (m, 2H, aromatic protons), 6.87-6.94 (m, 2H, aromatic protons), 4.90-4.98 (ddd, 1H, *J*=8.8 and 4.2 Hz, C*H*OAc), 4.47 (s, 2H, CH_2Ar), 3.83 (s, 3H, OCH_3), 3.74 (dt, 1H, *J*=10.6 and 4.2 Hz, CHN_3), 3.57 (dd, 2H, *J*=7.1 and 4.5 Hz, CH_2O), 2.12 (s, 3H, $COCH_3$), 1.75-1.84 (m, 1H, CH_2CH_2O), 1.56-1.68 (m, 2H, CH_2CH_3), 0.93 (t, 3H, *J*=7.4 Hz, CH_3). Anal.Calcd for $C_{16}H_{23}N_3O_4$: C, 59.80; H, 7.21; N, 13.07. Found: C, 59.01; H, 7.41; N, 13.29.

anti-4-Azido-1-(*p*-methoxybenzyloxy)-3-hexanol (**56**, R_1=PMB), a liquid: IR ν 2101 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.14-7.19 (m, 2H, aromatic protons), 6.78-6.82 (m, 2H, aromatic protons), 4.38 (s, 2H, CH_2Ar), 3.73 (s, 3H, OCH_3), 3.65-3.75 (m, 3H, CH_2O and C*H*OH), 3.16 (ddd, 1H, *J*=9.1 and 4.2 Hz,

CHN_3), 1.61-1.86 (m, 2H, CH_2CH_2O), 1.41-1.55 (m, 2H, CH_2CH_3), 1.0 (t, 3H, J=7.3 Hz, CH_3). Anal.Calcd for $C_{14}H_{21}N_3O_3$: C, 60.20; H, 7.58; N, 15.04. Found: C, 59.92; H, 7.49; N, 15.00. **Acetate** (**60**, R_1=PMB), a liquid: IR ν 2102, 1744 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.17-7.29 (m, 2H, aromatic protons), 6.87-6.82 (m, 2H, aromatic protons), 5.16 (ddd, 1H, J=8.4 and 4.2 Hz, $CHOAc$), 4.46 (ABdd, 2H, J=11.5 Hz, CH_2Ar), 3.82 (s, 3H, OCH_3), 3.44-3.54 (m, 3H, CH_2O and CHN_3), 2.05 (s, 3H, $COCH_3$), 1.87-1.94 (m, 2H, CH_2CH_2O), 1.41-1.53 (m, 2H, CH_2CH_3), 1.04 (t, 3H, J=7.3 Hz, CH_3). Anal.Calcd for $C_{13}H_{19}N_3O_2$: C, 62.63; H, 7.78; N, 16.85. Found: C, 62.80; H, 7.50; N, 16.61.

The crude reaction product (0.102 g) from the trans epoxide **18** was purified by semipreparative TLC (a 9:1 mixture of toluene and CH_2Cl_2 was used as the eluant). Extraction of the most intense band afforded pure **anti-4-azido-1-(*t*-butoxy)-3-hexanol** (**56**, R_1=*t*-Bu) (0.042 g), as a liquid: IR ν 2100 cm^{-1}; ^1H NMR ($CDCl_3$) δ 3.65 (ddd, 2H, J=8.7 and 4.7 Hz, CH_2O), 3.49 (ddd, 1H, J=8.8, 7.3, and 5.7 Hz), 3.16 (ddd, 1H, J=9.3, 5.7 and 3.8 Hz), 1.41-1.78 (m, 4H), 1.14 (s, 9H, *t*-Bu), 0.97 (t, 3H, J=7.3 Hz, CH_3). Anal.Calcd for $C_{10}H_{21}N_3O_2$: C, 55.79; H, 9.83; N, 19.52. Found: C, 55.63; H, 9.71; N, 19.48. **Acetate** (**60**, R_1=*t*-Bu), a liquid: IR ν 2101, 1743 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.01 (dt, 1H, J=9.3 and 3.6 Hz, $CHOAc$), 3.40 (ddd, 1H, J=8.9 and 3.9 Hz, CHN_3), 3.20-3.34 (m, 2H, CH_2O), 2.00 (s, 3H, $COCH_3$), 1.63-1.82 (m, 2H, CH_2CH_2O), 1.35-1.52 (m, 2H, CH_2CH_3), 1.06 (s, 9H, *t*-Bu), 0.93 (t, 3H, J=7.3 Hz, CH_3). Anal.Calcd for $C_{12}H_{23}N_3O_3$: C, 56.01; H, 9.01; N, 16.33. Found: C, 55.85; H, 9.08; N, 16.21. Due to TLC separation problems, the regioisomer **55** (R_1=*t*-Bu) was not obtained pure. However, its presence in the crude reaction product was clearly substantiated by GC and ^1H NMR evidence.

For the same reason, it was not possible to obtain the regioisomers **55** and **56** (R_1=H or Ac) (or their acetyl derivatives **59** and **60**, R_1=H or Ac, Scheme 4) pure from the opening reactions of the corresponding epoxides **14** and **19**. However their presence in the crude reaction product was clearly substantiated by GC and ^1H NMR evidences: **59** (R_1=Ac), ^1H NMR ($CDCl_3$) δ 4.90 (ddd, 1H, J=8.5 and 4.1 Hz, $CHOAc$), 4.17 (t, 2H, J=6.3 Hz, CH_2OAc), 3.62 (ddd, 1H, J=7.4 and 4.1 Hz, CHN_3), 2.10 (s, 3H, $COCH_3$), 0.92 (t, 3H, J=7.4 Hz, CH_3); **60** (R_1=Ac), ^1H NMR ($CDCl_3$) δ 5.03 (ddd, 1H, J=8.6 and 4.2 Hz, $CHOAc$), 4.13 (t, 2H, J=6.2 Hz, CH_2OAc), 3.48 (ddd, 1H, J=8.6 and 4.4 Hz, CHN_3), 2.09 (s, 3H, $COCH_3$), 1.02 (t, 3H, J=7.3 Hz, CH_3).

The crude acetylated product (0.143 g) from the cis epoxide **29** was purified by semipreparative TLC (an 85:15 mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the two most intense bands (the faster moving band containing **71**) afforded the pure azido diacetates **71** (0.052 g) and **72** (0.041 g).

syn-3-Azido-1-(benzyloxy)-2,4-(diacetoxy)butane (**71**), a liquid: IR ν 2112, 1745 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.19-7.33 (m, 5H, aromatic protons), 5.06 (dd, 1H, J=5.0 and 10.0 Hz, $CHOAc$), 4.48 (ABdd, 2H, J=11.9 Hz, CH_2Ph), 4.20 (dd, 1H, J=11.5 and 4.3 Hz, one proton of CH_2OAc), 4.05 (dd, 1H, J=11.5 and 7.4 Hz, one proton of CH_2OAc), 3.92 (dt, 1H, J=7.4 and 4.5 Hz, CHN_3), 3.57 (dd, 1H, J=10.2 and 5.4 Hz, one proton of CH_2OBn), 3.50 (dd, 1H, J=10.2 and 5.1 Hz, one proton of CH_2OBn), 2.00 (s, 3H, $COCH_3$), 1.99 (s, 3H, $COCH_3$). Anal.Calcd for $C_{15}H_{19}N_3O_5$: C, 56.07; H, 5.96; N, 13.08. Found: C, 55.85; H, 5.74; N, 13.15.

syn-2-Azido-1-(benzyloxy)-3,4-(diacetoxy)butane (**72**), a liquid: IR ν 2112, 1745 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.19-7.34 (m, 5H, aromatic protons), 5.18 (dt, 1H, J=6.3 and 4.5 Hz, $CHOAc$), 4.48 (s, 2H, CH_2Ph), 4.25 (dd, 1H, J=11.8 and 4.4 Hz, one proton of CH_2OAc), 4.05 (dd, 1H, J=11.8 and 6.3 Hz, one proton of CH_2OAc), 3.63-3.72 (m, 1H, CHN_3), 3.53-3.61 (m, 2H, CH_2OBn), 1.99 (s, 3H, $COCH_3$), 1.98 (s, 3H, $COCH_3$). Anal.Calcd for $C_{15}H_{19}N_3O_5$: C, 56.07; H, 5.96; N, 13.08. Found: C, 55.91; H, 5.81; N, 13.22.

The crude acetylated reaction product (0.184 g) from the cis epoxide **30** was purified by semipreparative TLC (a 90:10 mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **68**) afforded pure azido acetates **67** (0.064 g) and **68** (0.051 g) (R_1=TBDMS).

syn-2-Acetoxy-3-azido-1-(benzyloxy)-4-(*t*-butyldimethylsilyloxy)butane (**67**, R_1=TBDMS), a liquid: IR ν 2105, 1745 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.24-7.31 (m, 5H, aromatic protons), 5.07-5.16 (m, 1H, CHOAc), 4.49 (ABdd, 2H, J=12.0 Hz, CH_2Ph), 3.60-3.77 (m, 3H, CHN_3, CH_2OTBDMS), 3.56 (dd, 2H, J=5.3 and 1.8 Hz, CH_2OBn), 2.06 (s, 3H, $COCH_3$), 0.84 (s, 9H, *t*-Bu), 0.02 [s, 6H, $Si(CH_3)_2$]. Anal.Calcd for $C_{19}H_{31}N_3O_4Si$: C, 57.99; H, 7.94; N, 10.68. Found: C, 57.81; H, 7.82; N, 10.43.

syn-3-Acetoxy-2-azido-1-(benzyloxy)-4-(*t*-butyldimethylsilyloxy)butane (**68**, R_1=TBDMS), a liquid: IR ν 2105, 1745 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.24-7.31 (m, 5H, aromatic protons), 4.92-5.00 (m, 1H, CHOAc), 4.50 (s, 2H, CH_2Ph), 3.71-3.79 (m, 1H, CHN_3), 3.54-3.67 (m, 4H, CH_2OBn, CH_2OTBDMS), 1.99 (s, 3H, $COCH_3$), 0.81 (s, 9H, *t*-Bu), 0.01 [s, 6H, $Si(CH_3)_2$]. Anal.Calcd for $C_{19}H_{31}N_3O_4Si$: C, 57.99; H, 7.94; N, 10.68. Found: C, 57.85; H, 7.79; N, 10.51.

The crude acetylated product (0.20 g) from the cis epoxide **31** was purified by semipreparative TLC (a 95:5 mixture of hexane and ether was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **68**) afforded the pure azido aceatates **67** (0.062 g) and **68** (0.052 g) (R_1=TIPS).

syn-2-Acetoxy-3-azido-1-(benzyloxy)-4-(triisopropylsilyloxy)butane (**67**, R_1=TIPS), a liquid: IR ν 2105, 1749 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.20-7.34 (m, 5H, aromatic protons), 5.11 (dt, 1H, J=9.5 and 5.0 Hz, CHOAc), 4.48 (ABdd, 2H, J=11.9 Hz, CH_2Ph), 3.69-3.84 (m, 3H, CHN_3, CH_2OTIPS), 3.56 (d, 2H, J=5.3 Hz, CH_2OBn), 2.04 (s, 3H, $COCH_3$), 0.91-1.06 [m, 21H, 3 $CH(CH_3)_2$]. Anal.Calcd for $C_{22}H_{37}N_3O_4Si$: C, 60.66; H, 8.56; N, 9.65. Found: C, 60.41; H, 8.40; N, 9.51.

syn-3-Acetoxy-2-azido-1-(benzyloxy)-4-(triisopropylsilyloxy)butane (**68**, R_1=TIPS), a liquid: IR ν 2105, 1749 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.20-7.30 (m, 5H, aromatic protons), 4.99 (dt, 1H, J=9.9 and 4.9 Hz, CHOAc), 4.50 (s, 2H, CH_2Ph), 3.82-3.91 (m, 1H, CHN_3), 3.69-3.79 (m, 2H, CH_2OTIPS), 3.52-3.67 (m, 2H, CH_2OBn), 1.99 (s, 3H, $COCH_3$), 0.91-1.08 [m, 21H, 3 $CH(CH_3)_2$]. Anal.Calcd for $C_{22}H_{37}N_3O_4Si$: C, 60.66; H, 8.56; N, 9.65. Found: C, 60.51; H, 8.62; N, 9.71.

The crude acetylated product (0.213 g) from the cis epoxide **32** was purified by semipreparative TLC (a 9:1 mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **68**) afforded the pure acetylated azido alcohols **67** (0.067 g) and **68** (0.047 g) (R_1=Tr).

syn-2-Acetoxy-3-azido-1-(benzyloxy)-4-(trityloxy)butane (**67**, R_1=Tr), a liquid: IR ν 2105, 1749 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.09-7.39 (m, 20H, aromatic protons), 5.10 (dt, 1H, J=5 and 10 Hz, CHOAc), 4.25 (ABdd, 2H, J=11.8 Hz, CH_2Ph), 3.69-3.80 (m, 1H, CHN_3), 3.44 (dd, 1H, J= 5.0 and 10.1 Hz, one proton of CH_2OTr), 3.28 (dt, 2H, J=4.4 and 9.5 Hz, CH_2OBn), 3.10 (dd, 1H, J=6.4 and 10.1 Hz, one proton of CH_2OTr), 1.93 (s, 3H, $COCH_3$). Anal.Calcd for $C_{32}H_{31}N_3O_4$: C, 73.68; H, 5.99; N, 8.06. Found: C, 73.41; H, 5.72; N, 8.14.

syn-3-Acetoxy-2-azido-1-(benzyloxy)-4-(trityloxy)butane (**68**, R_1=Tr), a liquid: IR ν 2105, 1749 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.13-7.40 (m, 20H, aromatic protons), 5.05 (dt, 1H, J=10.3 and 4.8 Hz, *CH*OAc), 4.35 (ABdd, 2H, *J*=13.01 Hz, *CH*$_2$Ph), 3.90-3.98 (m, 1H, CHN$_3$), 3.52 (dd, 1H, *J*=9.9 and 3.6 Hz, one proton of *CH*$_2$OTr), 3.35 (dd, 1H, *J*=10.0 and 6.8 Hz, one proton of *CH*$_2$OTr), 3.25 (dd, 1H, *J*=10.1 and 4.7 Hz, one proton of *CH*$_2$OBn), 3.05 (dd, 1H, *J*=10.2 and 4.7 Hz, one proton of *CH*$_2$OBn), 2.03 (s, 3H, COCH$_3$). Anal.Calcd for $C_{32}H_{31}N_3O_4$: C, 73.68; H, 5.99; N, 8.06. Found: C, 73.60; H, 5.81; N, 8.16.

The crude acetylated reaction product (0.142 g) from the trans epoxide **33** was subjected to semipreparative TLC (an 85:15 mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **74**) afforded the pure azido diacetates **73** (0.050 g) and **74** (0.041 g).

anti-3-Azido-1-(benzyloxy)-2,4-(diacetoxy)butane (**73**), a liquid: IR ν 2112, 1757 cm^{-1}; ^{1}H NMR (CDCl$_3$) δ 7.19-7.29 (m, 5H, aromatic protons), 4.96 (dt, 1H, *J*=6.9 and 4.2 Hz, *CH*OAc), 4.48 (s, 2H, *CH*$_2$Ph), 4.10-4.26 (m, 2H, *CH*$_2$OAc), 3.91-4.00 (m, 1H, CHN$_3$), 3.59 (dd, 2H, *J*=4.3 and 2.1 Hz, *CH*$_2$OBn), 2.03 (s, 3H, COCH$_3$), 2.02 (s, 3H, COCH$_3$). Anal.Calcd for $C_{15}H_{19}N_3O_4$: C, 56.07; H, 5.96; N, 13.08. Found: C, 56.13; H, 5.81; N, 13.40.

anti-2-Azido-1-(benzyloxy)-3,4-(diacetoxy)butane (**74**), a liquid: IR ν 2112, 1757 cm^{-1}; ^{1}H NMR (CDCl$_3$) δ 7.19-7.31 (m, 5H, aromatic protons), 4.99 (dt, 1H, *J*=6.7 and 4.3 Hz, *CH*OAc), 4.5 (ABdd, 2H, *J*=10.4 Hz, *CH*$_2$Ph), 4.33 (dd, 1H, *J*=12.3 and 3.1 Hz, one proton of *CH*$_2$OAc), 4.10 (dd, 1H, *J*=12.3 and 5.8 Hz, one proton of *CH*$_2$OAc), 3.78 (dt, 1H, *J*=6.9 and 3.8 Hz, CHN$_3$), 3.60 (dd, 1H, *J*=10.0 and 3.8 Hz, one proton of *CH*$_2$OBn), 3.49 (dd, 1H, *J*=10.0 and 6.9 Hz, one proton of *CH*$_2$OBn), 1.98 (s, 3H, COCH$_3$), 1.99 (s, 3H, COCH$_3$). Anal.Calcd for $C_{15}H_{19}N_3O_4$: C, 56.07; H, 5.96; N, 13.08. Found: C, 56.16; H, 5.81; N, 13.01.

The crude acetylated reaction product (0.182 g), from the trans epoxide **34** was purified by semipreparative TLC (a 80:20 mixture of hexane and AcOEt was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **70**) afforded the pure acetilated azido alcohols **69** (0.083 g) and **70** (0.041 g) (R$_1$=TBDMS).

anti-2-Acetoxy-3-azido-1-(benzyloxy)-4-(*t*-butyldimethylsilyloxy)butane (**69**, R$_1$=TBDMS), a liquid: IR ν 2112, 1757 cm^{-1}; ^{1}H NMR (CDCl$_3$) δ 7.18-7.33 (m, 5H, aromatic protons), 4.94-5.01 (m, 1H, *CH*OAc), 4.47 (ABdd, 2H, *J*=12.1 Hz, *CH*$_2$Ph), 3.57-3.80 (m, 5H, CHN$_3$, *CH*$_2$OBn, *CH*$_2$OTBDMS), 2.02 (s, 3H, COCH$_3$), 0.83 (s, 9H, *t*-Bu), 0.01 [s, 6H, Si(CH$_3$)$_2$]. Anal.Calcd for $C_{19}H_{31}N_3O_4Si$: C, 57.99; H, 7.94; N, 10.68. Found: C, 57.81; H, 7.70; N, 10.51.

anti-3-Acetoxy-2-azido-1-(benzyloxy)-4-(*t*-butyldimethylsilyloxy)butane (**70**, R$_1$=TBDMS), a liquid: IR ν 2112, 1757 cm^{-1}; ^{1}H NMR (CDCl$_3$) δ 7.19-7.26 (m, 5H, aromatic protons), 4.83 (dt, 1H, *J*=8.6 and 4.3 Hz, *CH*OAc), 4.49 (s, 2H, *CH*$_2$Ph), 3.36-3.87 (m, 5H, CHN$_3$, *CH*$_2$OBn, *CH*$_2$OTBDMS), 2.02 (s, 3H, COCH$_3$), 0.81 (s, 9H, *t*-Bu), 0.01 [s, 6H, Si(CH$_3$)$_2$]. Anal.Calcd for $C_{19}H_{31}N_3O_4Si$: C, 57.99; H, 7.94; N, 10.68. Found: C, 57.80; H, 7.81; N, 10.49.

The crude acetylated reaction product (0.195 g) from the trans epoxide **35** was purified by semipreparative TLC (a 9:1 mixture of hexane and AcOEt was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **70**) afforded pure azido acetates **69** (0.084 g) and **70** (0.045 g) (R$_1$=TIPS).

anti-2-Acetoxy-3-azido-1-(benzyloxy)-4-(triisopropylsilyloxy)butane (**69**, R$_1$=TIPS), a liquid: IR ν 2112, 1757 cm^{-1}; ^{1}H NMR (CDCl$_3$) δ 7.18-7.28 (m, 5H, aromatic protons), 4.94-5.01 (m, 1H, C*H*OAc), 4.47 (ABdd, 2H, *J*=12.0 Hz, C*H*$_2$Ph), 3.68-3.86 (m, 3H, CHN$_3$, C*H*$_2$OTIPS), 3.59 (d, 2H, *J*=4.3 Hz, C*H*$_2$OBn), 2.01 (s, 3H, COCH$_3$), 0.95-1.01 [m, 21H, 3 CH(CH$_3$)$_2$]. Anal.Calcd for $C_{22}H_{37}N_3O_4Si$: C, 60.66; H, 8.56; N, 9.65. Found: C, 60.59; H, 8.51; N, 9.59.

anti-3-Acetoxy-2-azido-1-(benzyloxy)-4-(triisopropylsilyloxy)butane (**70**, R_1=TIPS), a liquid: IR ν 2112, 1757 cm^{-1}; ^{1}H NMR (CDCl$_3$) δ 7.19-7.28 (m, 5H, aromatic protons), 4.85 (dt, 1H, *J*=8.5 and 4.3 Hz, C*H*OAc), 4.49 (ABdd, 2H, *J*=11.9 Hz, C*H*$_2$Ph), 3.90 (dt, 1H, *J*=7.3 and 3.2 Hz, CHN$_3$), 3.80 (d, 2H, *J*=4.3 Hz, C*H*$_2$OTIPS), 3.47-3.65 (m, 2H, C*H*$_2$OBn), 1.95 (s, 3H, COCH$_3$), 0.96-1.00 [m, 21H, 3 CH(CH$_3$)$_2$]. Anal.Calcd for $C_{22}H_{37}N_3O_4Si$: C, 60.66; H, 8.56; N, 9.65. Found: C, 60.49; H, 8.49; N, 9.51.

Due to TLC separation problem, the acetylated compounds **69** and **70** (R_1=Tr) derived from the trans epoxide **36** were not obtained pure. As a consequence, the crude reaction mixture of **69** and **70** (R_1=Tr) was subjected to the deprotection-acetylation procedure (see general procedure) to give a crude product consisting of a corresponding mixture of the diacetates **73** and **74** (GC and ^{1}H NMR).

The acetyl derivatives **83** and **84** (R_1=PMB) of the regioisomers **79** and **80** (R_1=PMB) obtained in the opening reaction of the trans epoxide **49**, were not obtained pure. However their presence was firmly substantiated by GC and ^{1}H NMR evidences: **83**, ^{1}H NMR (CDCl$_3$) δ 5.05-5.13 (m, 1H, C*H*OAc); **84**, ^{1}H NMR (CDCl$_3$) δ 4.95-5.04 (m, 1H, C*H*OAc).

The crude acetylated reaction product (0.197 g) from the trans epoxide **50** was purified by semipreparative TLC (a 90:10: 0.1 mixture of petroleum ether, diisopropyl ether and MeOH was used as the eluant). Extraction of the two most intense bands (the faster moving contained **83**) afforded the pure azido acetate **83** (0.047 g) and **84** (0.095 g) (R_1=TIPS).

anti-3-Acetoxy-2-azido-5-(benzyloxy)-1-(triisopropylsilyloxy)pentane (**83**, R_1=TIPS), a liquid: IR ν 2102, 1745 cm^{-1}; ^{1}H NMR (CDCl$_3$) δ 7.26-7.36 (m, 5H, aromatic protons), 5.13 (ddd, 1H, *J*=8.1 and 4.0 Hz, C*H*OAc), 4.46 (ABdd, 2H, *J*=11.6 Hz, C*H*$_2$Ph), 3.72-3.86 (m, 4H), 3.49 (ddd, 1H, *J*=11.5 and 5.9 Hz), 2.02 (s, 3H), 1.86-1.97 (m, 2H), 0.96-1.07 [m, 21H, 3 CH(CH$_3$)$_2$]. Anal.Calcd for $C_{23}H_{39}N_3O_4Si$: C, 61.44; H, 8.74; N, 9.34. Found: C, 61.41; H, 8.68; N, 9.31.

anti-2-Acetoxy-3-azido-5-(benzyloxy)-1-(triisopropylsilyloxy)pentane (**84**, R_1=TIPS), a liquid: IR ν 2106, 1749 cm^{-1}; ^{1}H NMR (CDCl$_3$) δ 7.26-7.34 (m, 5H, aromatic protons), 4.94 (dt, 1H, *J*=10.3 and 4.9 Hz, C*H*OAc), 4.52 (s, 2H, C*H*$_2$Ph), 3.85-4.00 (m, 3H), 3.61 (dd, 2H, *J*=7.6 and 4.6 Hz), 2.07 (s, 3H), 1.91-2.03 (m, 1H), 1.59-1.76 (m, 1H), 0.93-1.06 [m, 21H, 3 CH(CH$_3$)$_2$]. Anal.Calcd for $C_{23}H_{39}N_3O_4Si$: C, 61.44; H, 8.74; N, 9.34. Found: C, 61.40; H, 8.88; N, 9.50.

The exact structure and regiochemistry of **84** was established by its transformation into the corresponding diacetate through the deprotection (TBAF in THF)-acetylation sequence to give **anti-3-azido-5-(benzyloxy)-1,2-(diacetoxy)-pentane**, as a liquid: IR ν 2108, 1747 cm^{-1}; ^{1}H NMR (CDCl$_3$) δ 7.20-7.30 (m, 5H, aromatic protons), 5.03 (ddd, 1H, *J*=6.5, 4.5 and 3.2 Hz, C*H*OAc), 4.45 (s, 2H, C*H*$_2$Ph), 4.30 (dd, 1H, *J*=12.2 and 3.1 Hz, one proton of CH$_2$OAc), 4.10 (dd, 1H, *J*=12.2 and 6.5 Hz, one proton of CH$_2$OAc), 3.81 (ddd, 1H, *J*=10.2 and 4.5 Hz, CHN$_3$), 3.53 (dd, 2H, *J*=7.4 and 4.4 Hz, C*H*$_2$OBn), 2.03 (s, 3H, COCH$_3$), 1.99 (s, 3H, COCH$_3$), 1.69-1.97 (m, 1H), 1.50-1.65 (m, 1H). Anal.Calcd for $C_{16}H_{21}N_3O_5$: C, 57.3; H, 6.31; N, 12.53. Found: C, 57.42; H, 6.50; N, 12.22.

The crude acetylated reaction product (0.166 g) from the trans epoxide **51** was purified by semipreparative TLC (a mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the most intense band afforded pure **anti-2-acetoxy-3-azido-1-(benzyloxy)-5-(*t*-butyldimethylsilyloxy)-pentane (86)** (0.102 g), as a liquid: IR ν 2108, 1745 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.17-7.30 (m, 5H, aromatic protons), 5.07 (X part of an ABX system, 1H, C*H*OAc), 4.52 (s, 2H, C*H*$_2$Ph), 3.88 (ddd, 1H, *J*=10.2, 5.2 and 3.3 Hz, CHN_3), 3.71 (ddd, 2H, J=4.3 Hz, C*H*$_2$OTBDMS), 3.63 (AB part of an ABX system, 8 lines, 2H, C*H*$_2$OBn), 2.08 (s, 3H, $COCH_3$), 1.43-1.83 (m, 2H), 0.88 (s, 9H, *t*-Bu), 0.05 [s, 6H, -Si(CH_3)$_2$]. Anal.Calcd for $C_{20}H_{33}N_3O_4Si$: C, 58.94; H, 8.16; N, 10.31. Found: C, 58.88; H, 8.21; N, 10.54. Due to TLC separation problem, the regioisomer **85** (R_1=TBDMS) was not obtained pure. However, its presence was substantiated by GC and ^1H NMR evidence: ^1H NMR ($CDCl_3$) δ 4.88 (ddd, 1H, *J*=10.0 and 4.8 Hz, C*H*OAc).

Azidolysis of Epoxides 13-19, 29-36 and 48-51 with $LiClO_4/NaN_3$ or $Mg(ClO_4)_2/NaN_3$ in MeCN. General Procedure. A solution of the epoxide (0.5 mmol) in MeCN (1.0 ml) was treated with anhydrous $LiClO_4$ (0.532 g, 5.0 mmol) or $Mg(ClO_4)_2$ (0.557 g, 2.5 mmol) and NaN_3 (0.049 g, 0.75 mmol) and the resulting reaction mixture was stirred at 80°C for 18h. After cooling, dilution with water, extraction with ether, and evaporation of the washed (water) ether extracts afforded a mixture of the corresponding azido alcohols which was analyzed, before and after acetylation, by GC and ^1H NMR. In some cases (epoxides **29**, **30**, **33**, and **34**) the same reaction was carried out in MeOH as the solvent and 17 M $LiClO_4$ as the promoting metal salt. In the case of the cis **29** and trans **33** epoxy alcohol, NH_4ClO_4 (0.088 g, 0.75 mmol) was added to the starting reaction mixture.

The crude acetylated reaction product (0.16 g) obtained from the $LiClO_4$-promoted azidolysis of the trans epoxide **48** afforded pure **anti-2-acetoxy-3-azido-1,5-(dibenzyloxy)pentane** (**84**, R_1=Bn), as a liquid: IR ν 2106, 1745 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.16-7.29 (m, 10H, aromatic protons), 5.01 (ddd, 1H, *J*=5.3 and 4.6 Hz, C*H*OAc), 4.47 (s, 2H, C*H*$_2$Ph), 4.46 (s, 2H, C*H*$_2$Ph), 3.85 (ddd, 1H, *J*=10.3 and 5.3 Hz, CHN_3), 3.49-3.60 (m, 4H, 2 C*H*$_2$OBn), 2.03 (s, 3H, $COCH_3$), 1.78-1.91 (m, 1H), 1.53-1.68 (m, 1H). Anal.Calcd for $C_{21}H_{25}N_3O_4$: C, 65.78; H, 6.57; N, 10.96. Found: C, 65.66; H, 6.50; N, 10.81.

The crude acetylated reaction product (0.164 g) obtained from the $Mg(ClO_4)_2$-promoted azidolysis of the trans epoxide **48** was subjected to semipreparative TLC (a 95:5 mixture of benzene and ether was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **84**) afforded **84** (R_1=Bn) (0.050 g) and pure **anti-3-acetoxy-2-azido-1,5-(dibenzyloxy)pentane** (**83**, R_1=Bn) (0.070 g), as a liquid; IR ν 2104, 1743 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.18-7.36 (m, 10H, aromatic protons), 5.07 (ddd, 1H, *J*=8.4 and 4.2 Hz, C*H*OAc), 4.47 (s, 2H, C*H*$_2$Ph), 4.46 (s, 2H, C*H*$_2$Ph), 3.88 (ddd, 1H, *J*=8.4 and 4.2 Hz, CHN_3), 3.34-3.57 (m, 4H, 2 C*H*$_2$OBn), 1.92 (s, 3H, $COCH_3$), 1.59-1.98 (m, 2H). Anal.Calcd for $C_{21}H_{25}N_3O_4$: C, 65.78; H, 6.57; N, 10.96. Found: C, 65.55; H, 6.42; N, 10.80.

Azidolysis of Epoxide 29 with $LiClO_4/NaN_3$ in MeCN. Following the general procedure described above, the reaction of the cis epoxide **29** (0.194 g, 1.0 mmol) in MeCN (2.0 ml) with NaN_3 (0.097 g, 1.5 mmol) and $LiClO_4$ (1.063 g, 10.0 mmol) afforded a crude reaction product (0.18 g) which was acetylated with Ac_2O to give a liquid product, mostly consisting of the diacetate **90** (GC and ^1H NMR).[11] Semipreparative TLC (an 8:2 mixture of petroleum ether and AcOEt was used as the eluant), and extraction of the most intense band afforded pure **syn-4-azido-1-(benzyloxy)-2,3-(diacetoxy)butane (90)**, as a liquid: ^1H NMR ($CDCl_3$) δ 7.14-7.27 (m, 5H, aromatic protons), 5.12-5.25 (m, 2H, 2 C*H*OAc), 4.39 (ABdd, *J*=12.0 Hz, C*H*$_2$Ph), 3.46 (d, 2H, *J*=4.8 Hz, C*H*$_2$OBn), 3.32 (dd, 2H, *J*=5.6 and 4.3 Hz, C*H*$_2$$N_3$), 1.97 (s, 3H, $COCH_3$), 1.96 (s, 3H, $COCH_3$). Anal.Calcd for $C_{15}H_{19}N_3O_5$: C, 56.07; H, 5.96; N, 13.08. Found: C, 56.14; H, 6.00; N, 13.25.

References and Notes

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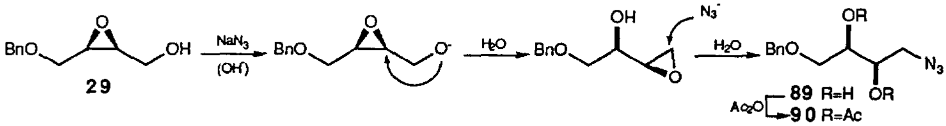
11. It is interesting to note that the azidolysis reaction of the cis **29** and trans **33** epoxides under metal salt-promoted conditions had to be slightly modified. In fact, due to the basicity of the reaction medium, the usual protocol (NaN_3/metal salt in MeCN) afforded almost exclusively the Payne rearrangement product (compound **89** from the cis epoxide **29**).[12] The preventive addition of an equivalent amount of NH_4ClO_4 to the reaction mixture avoided this undesirable side reaction.



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